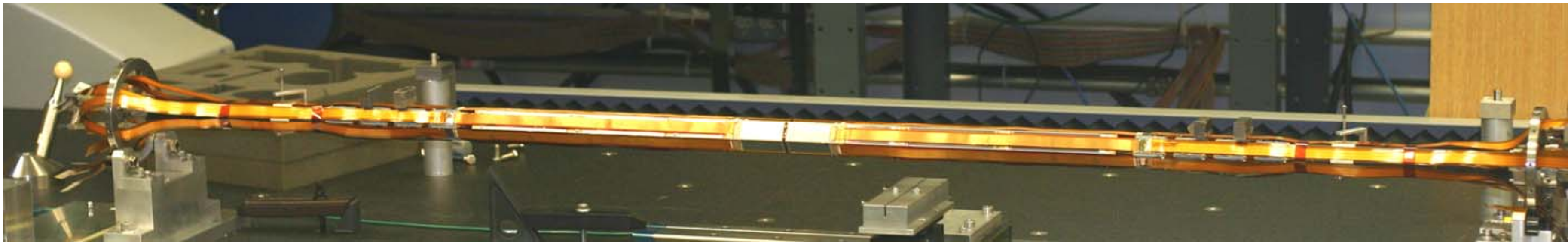


L0 Silicon Mechanical Installation

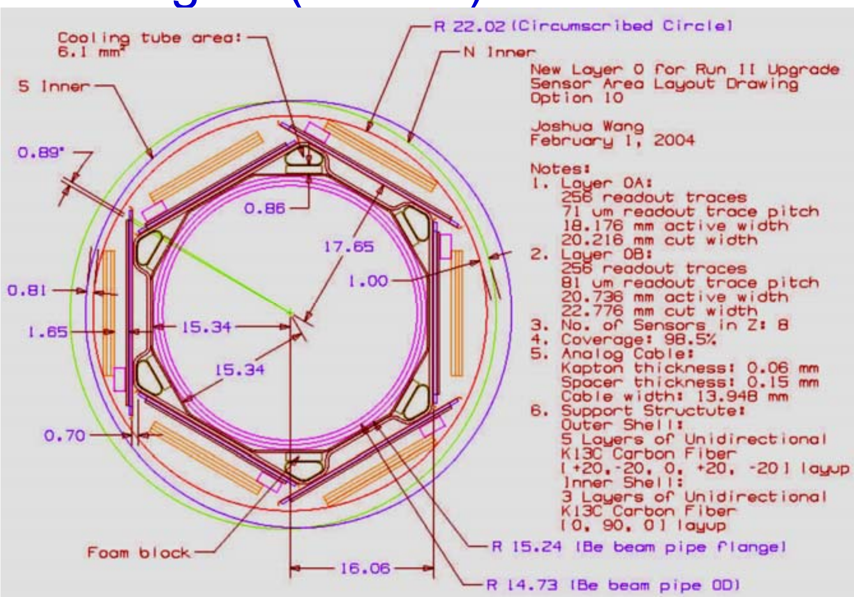
Bill Cooper

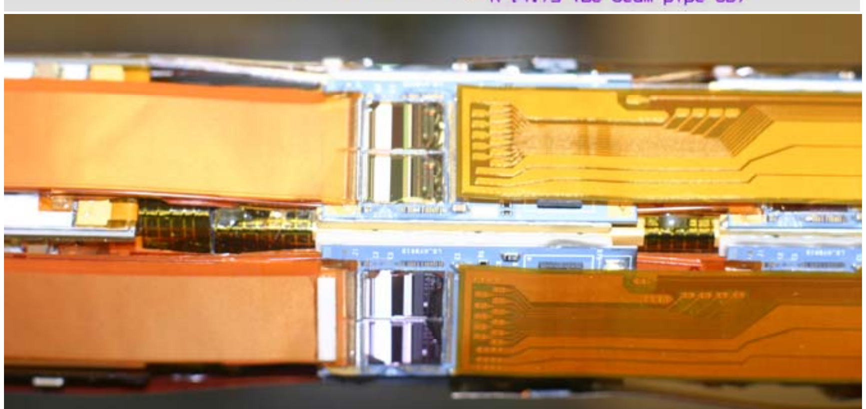
Status

- Except for final dotting of i's and crossing of t's, L0 is finished, works well, and we know how to install it.
- The last module was installed 8/1/05.
- Electrical testing (full-system test) was completed 9/16/05.
  - Testing included two thermal cycles in which sensor temperatures reached -8^{o} C.
  - No issues arose from low temperature operation.
- All sensors read out properly.
  - Thanks to careful and diligent work, noise is low.
  - Addition of a filter on SVX low voltage lines turned out to be critical.
- RTD's for temperature measurements work.
  - SVX4 readout system noise associated with RTD lines was encountered in the SiDet testing.
  - Most of that noise was eliminated by enclosing twisted pairs from the end of L0 to the adapter card ring in shield braid grounded at the adapter card ring.
  - A filter network may be needed as well.

L0 Design (1)

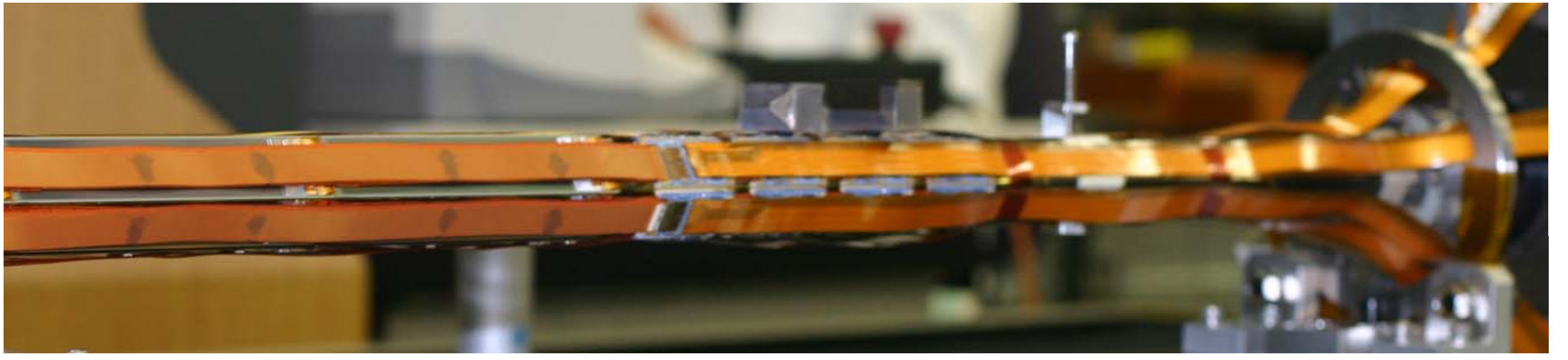
- Sensor region (top) & hybrid region (bottom)





- L0 was designed to fit within a radius of 22.02 mm.
- To provide overlap in phi, sensors were mounted at two different radii.
  - Overlap in phi = 98.4%
- PEEK cooling tubes are imbedded between inner and outer CF support cylinders.
- As a function of Z, spacers position hybrids at slightly different radii to allow analogue cables to pass beneath the hybrids.
- All digital cables pass above hybrids.

L0 Design (2)



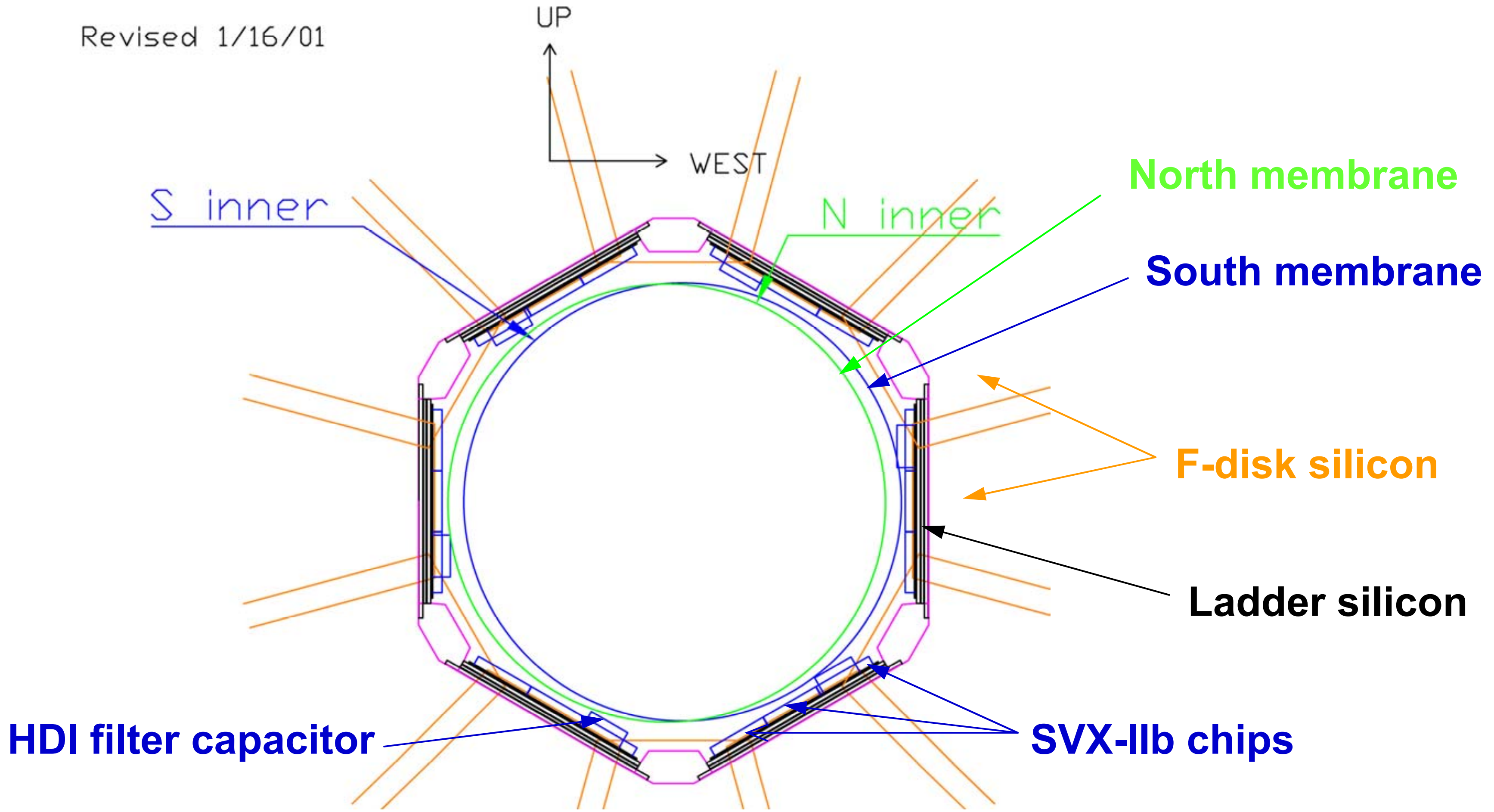
Sensors and analogue cables   Hybrids   Digital cables

Support structures provided by U. Washington.

- The overall L0 length is 1660 mm.
- The length of the sensor region is 770 mm.
- Carbon fiber structures support sensors and hybrids.
- Based upon re-measurements of sensor fiducials after epoxy had cured, sensor positions appear to match target locations to ~ 3 μm.
- Target locations compensated for predicted gravitational deflections of the support structure, which changed as modules were installed.
- The most visible feature of the completed L0 is cabling.

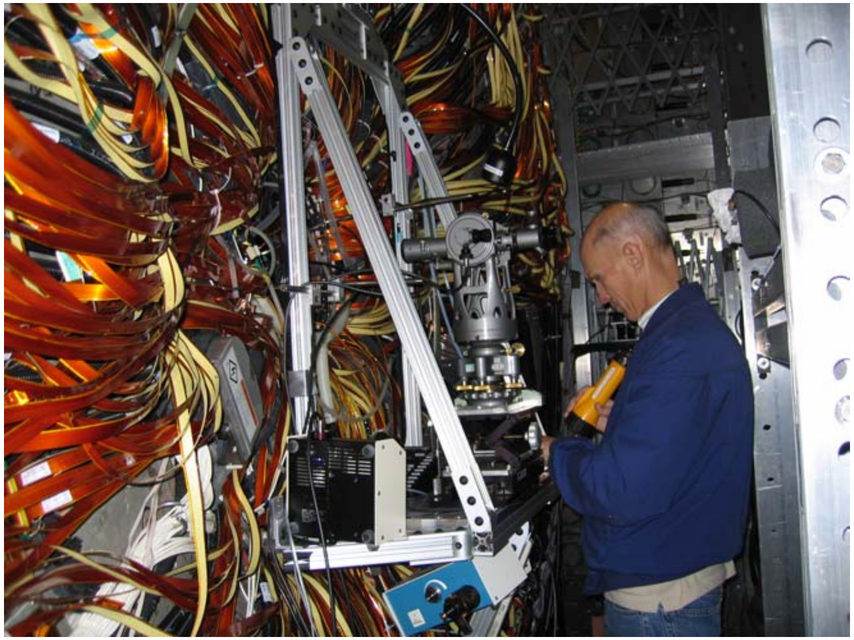
Limiting Installation Aperture

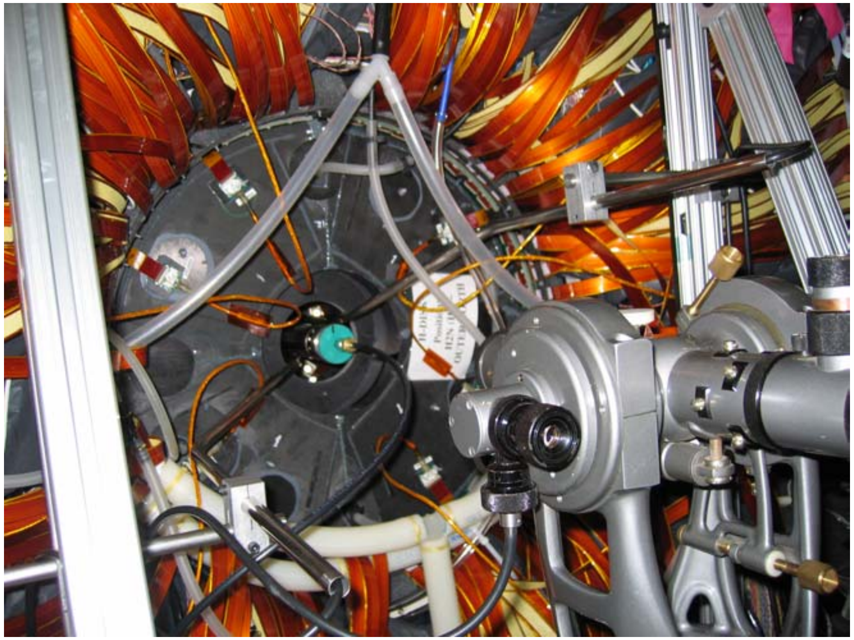
- The drawing below shows Run IIa silicon and the apertures of Run IIa Z = 0 support structure membranes. The nearest objects, ladder filter capacitors, are ~ 1 mm outside the aperture of the membranes.



Aperture Measurements

- Installation aperture is clearly an issue.
- CMM data from Run IIa were evaluated to determine what aperture should be assumed during L0 design.
- To confirm those predictions, measurements of the aperture through Run IIa silicon were made during the Fall 2004 shutdown.





- A Brunson survey instrument was supported from tables and stages.
- The beam pipe was disconnected but remained in place.

Summary of Aperture Measurements

- From CMM data, we knew that openings in north and south Z = 0 membranes were not aligned.
- Measurements confirmed the most restrictive aperture is at that location.
- Other apertures are sufficiently circular and well aligned that installation clearance is not an issue.
- Apertures were measured from north and south based upon opening diameters and centers and also based upon direct east – west measurements.
- For a L0 that fits within a cylinder of radius 22.02 mm, the radial clearance vertically is 1.67 mm; the radial clearance horizontally is 0.86 mm.
- The larger vertical aperture limits complications from gravitational deflection during installation.

Aperture Diameters at Z = 0

- By combining measured opening centers and measured opening diameters, we obtain the following apertures (in mm) at Z = 0.

Aperture	Survey from north	Survey from south	CMM
Horizontal	45.755	45.788	45.884
Vertical	47.388	47.481	47.492

- We also obtained the horizontal aperture directly by comparing measurements of east and west edges (fewer measurement points per membrane).

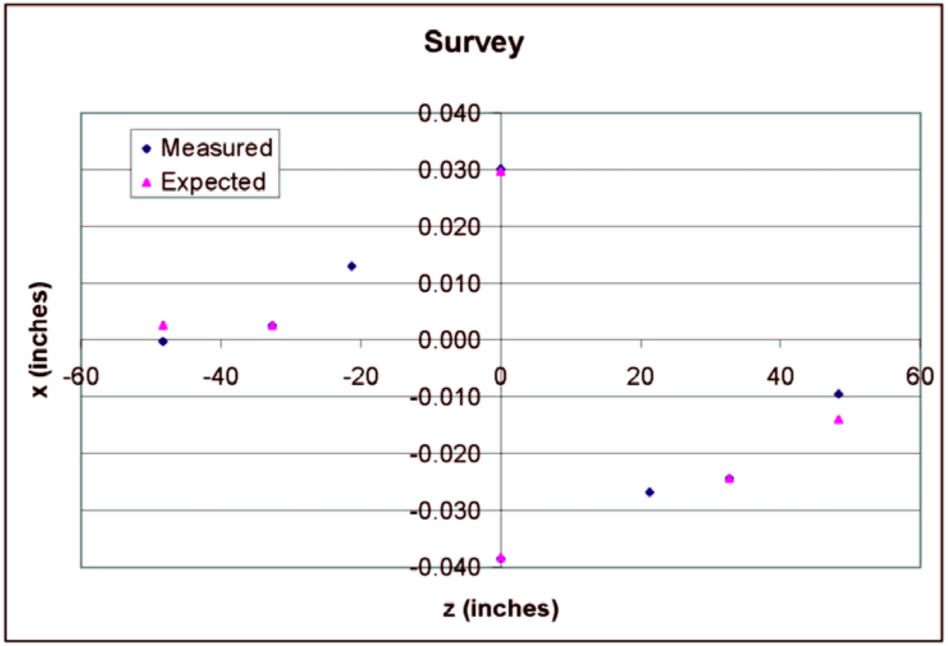
Aperture	Survey from north	Survey from south
Horizontal	45.792	45.784

- To be conservative, we have taken the available aperture to be the smallest obtained from the various measurements:
  - 45.755 mm horizontally and 47.388 mm vertically.

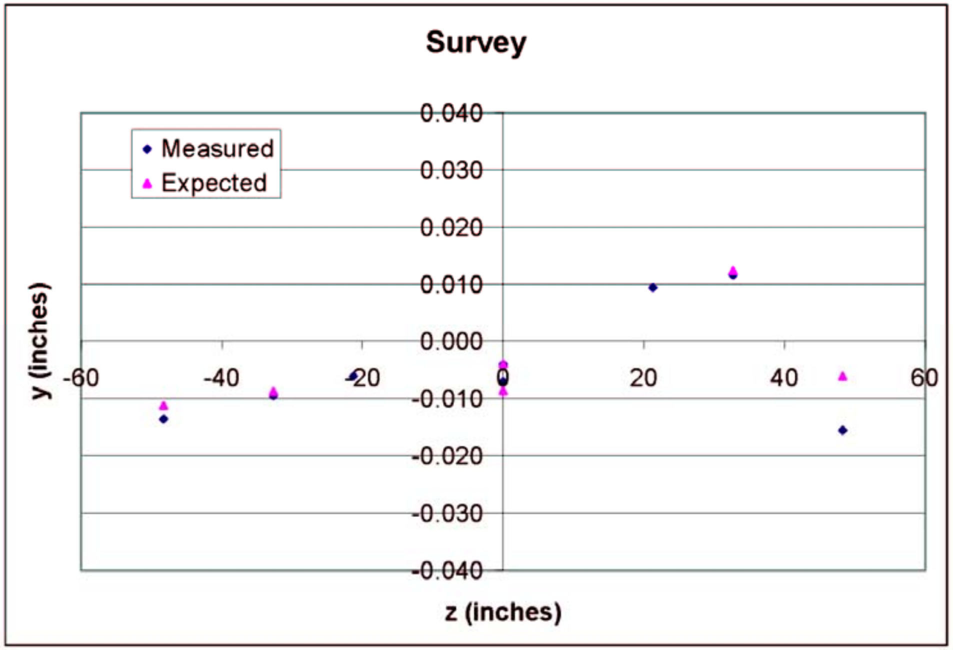
Alignment of Apertures

- Membrane hole centers versus Z (inches)
  - Z increases from north to south
- Survey in blue, combined CMM data in magenta
- Leftmost and rightmost data are for the beam pipe flanges and reflect accuracy limitations in placing the beam pipe and maintaining its position.
- The expected 0.068" step at Z = 0 in cylinder membrane positions is evident in the left plot.

Horizontal (+ = east)

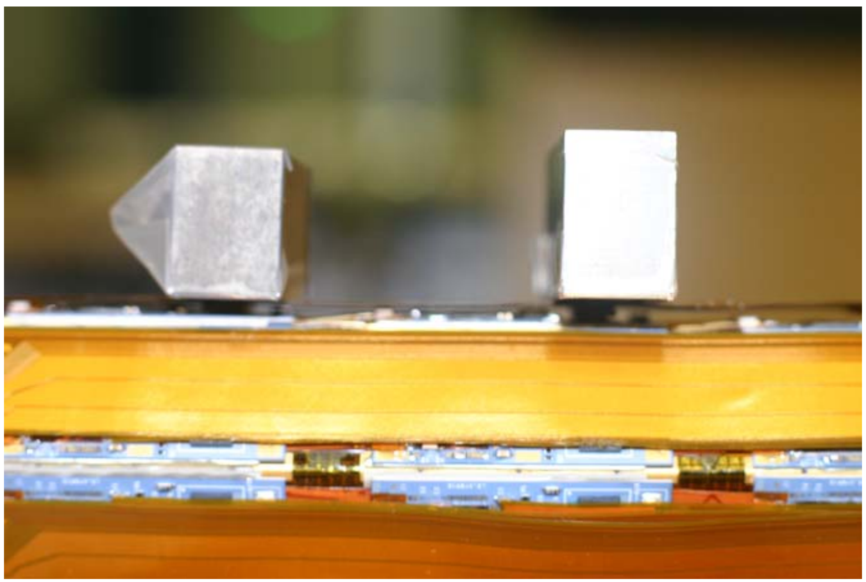


Vertical (+ = up)



Cable Anchoring

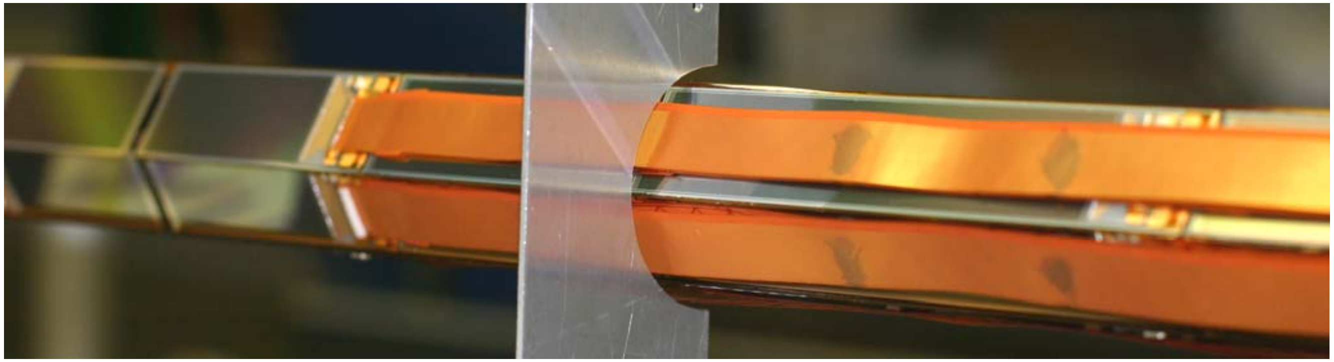
- Analogue cables, which could extend beyond the L0 design radius if unconstrained, were anchored as modules were installed.
  - Slack was provided to allow for cable contraction due to temperature and humidity changes.
- Digital cables are anchored at hybrid connectors and, at larger Z, at a constraint and support ring; slack is provided.

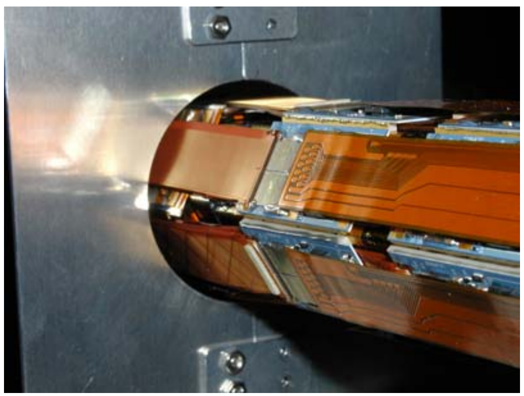


Cable stacks being glued to hybrid connectors

Cable stacks being glued to Z-constraint and installation support ring beyond the hybrid region

Installation Aperture





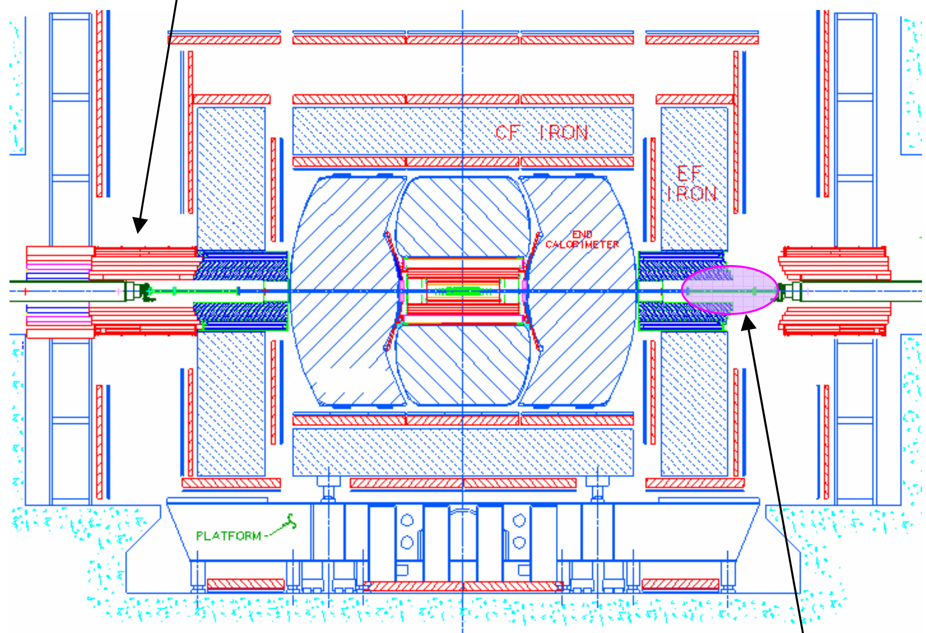
- Preliminary inspections indicate that all structures close to the aperture limit lie within their design radii.
- Template radius matches the tightest radial aperture of the Run IIa silicon support structure.
  - That is the horizontal aperture at the Z = 0 membrane overlap.

Overview of L0 Installation Sequence (1)

1. Start - Detector is in closed position

2. Open shielding. Open EF and remove BLM's. Temporarily lock EC beam pipe axial location to EC collar. Close EF. Remove VETO counters. Remove quad bellows assembly and SNEG. Install remotely compressible beam pipe spacer between EC flange and quad. [Telescoping ladder upright, flanged with 40" stroke]

Shielding moves into truss



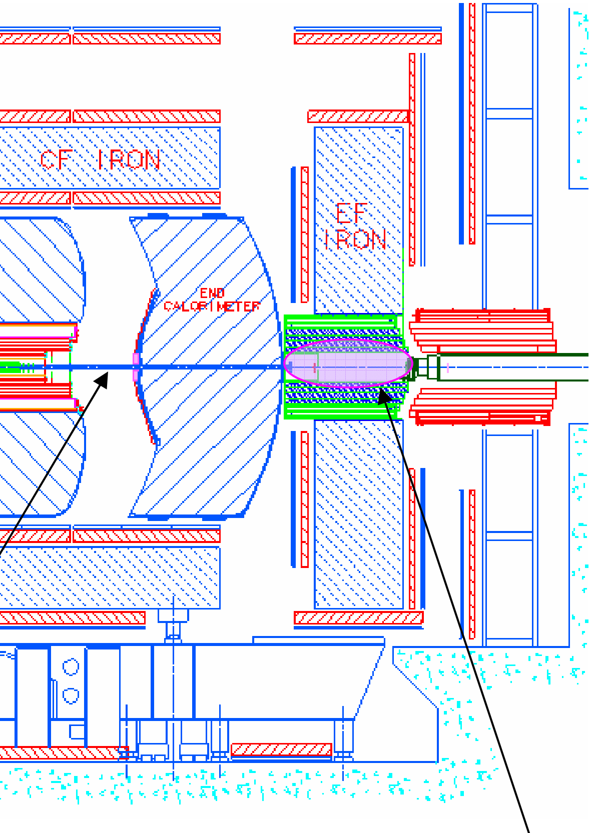
Remove outer beam pipes.
Replace w/collapsible piece

Steps provided by Russ Rucinski

Overview of L0 Installation Sequence (2)

3. Open EF's. Remove temporary EC beam pipe restraint. Open CF's. Open End Calorimeters. Detector is now in full open position.

   Disconnect inner beam pipe joints. Partially displace EC pipes towards quads. Cut reducer off the EC beam pipe. Fully displace EC pipes toward quads. Remove H-disks. Remove 2A Be pipe, put it inside the north EC beam pipe. Return NEC pipe to it's normal axial location.

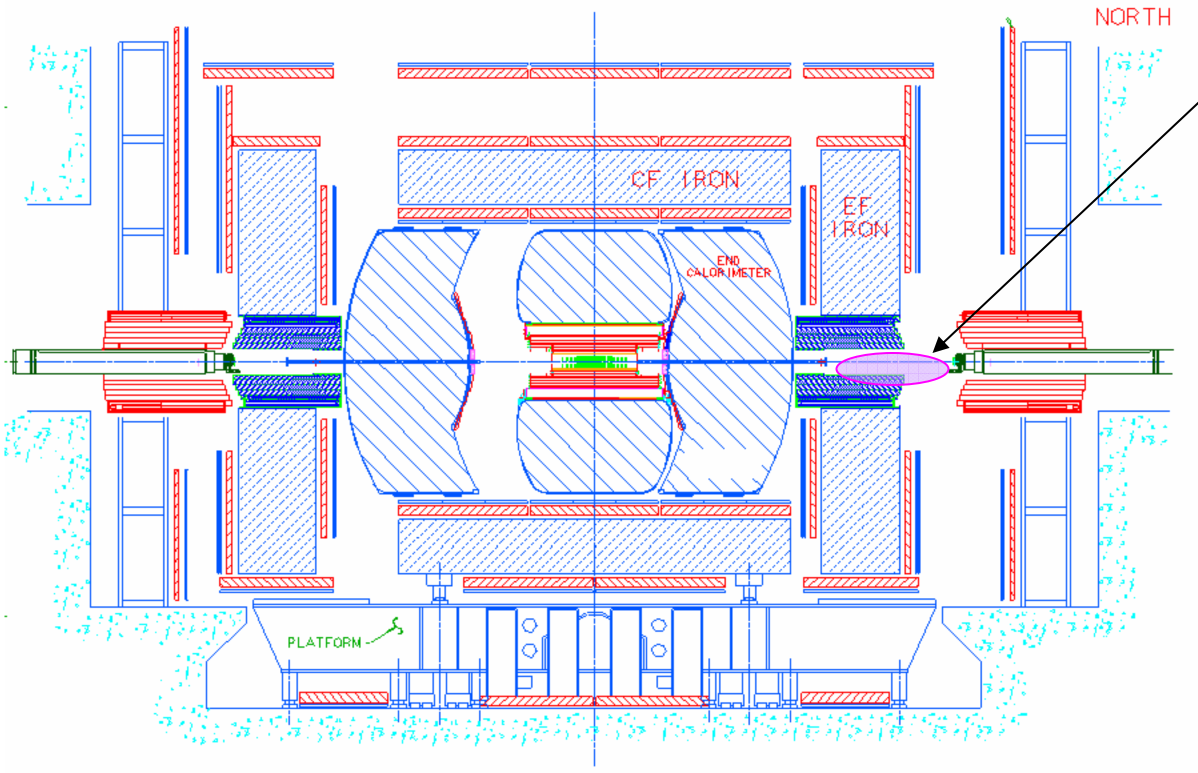


40" Gap opens up to enable inside work

Collapse from ~67" to ~27".

Overview of L0 Installation Sequence (3)

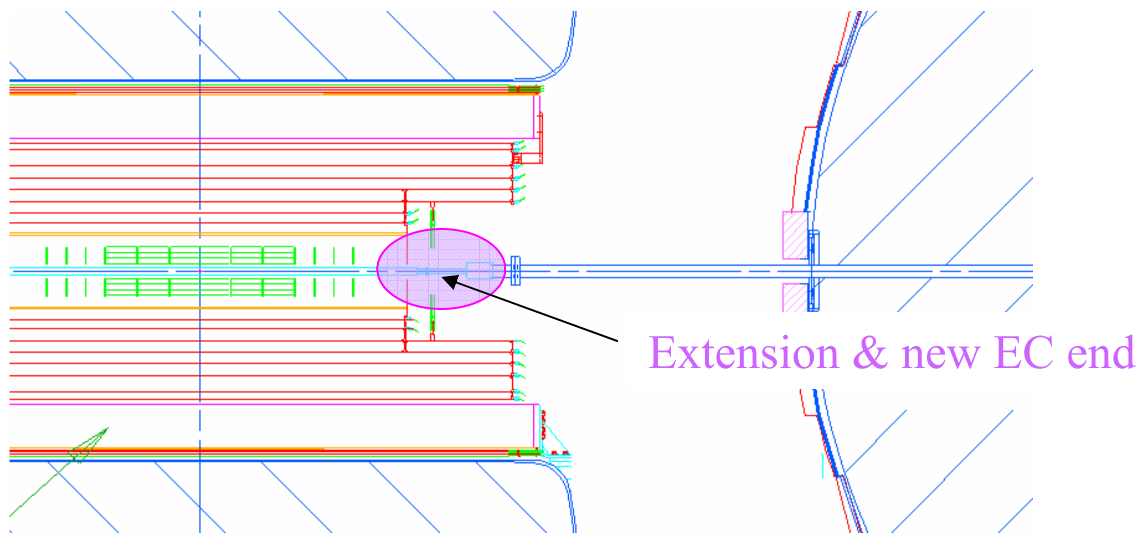
4. Close ECN. Install limit device between EC pipe and EC collar. Close EFN. Remove compressible beam pipe sections. Translate ECN pipe 17” further towards the tracker. Remove 2A Be pipe from north EC. Insert L0 and run 2B pipe inside the north EC beam pipe. Re-Install compressible beam pipe section on north side.



2A pipe comes out.
L0 & 2B pipe go in.

Overview of L0 Installation Sequence (4)

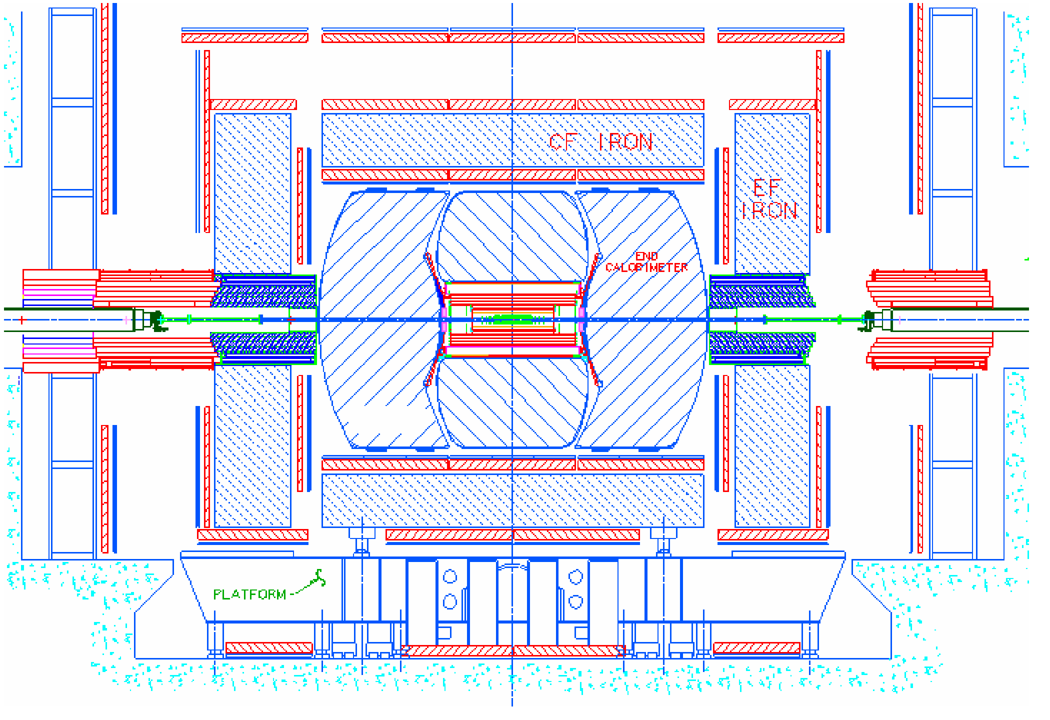
5. Open EFN and ECN. Displace EC pipe towards quads. Install L0 mounts. Assemble long installation tool in south gap. Install L0, and 2B Be pipe. Store long installation tool in south EC pipe. Weld on EC flanges. Make cooling and electrical connections to L0. Connect beam pipe extension spools to 2B pipe. Leak check innermost beam pipe joints and EC welds. Disconnect and retract EC pipe. Install inner H-disks. Install beam pipe support. Connect EC beam pipes to beam pipe extension spools. Bag joints for remote leak check. Install foam and tedlar to close out tracker.



Overview of L0 Installation Sequence (5)

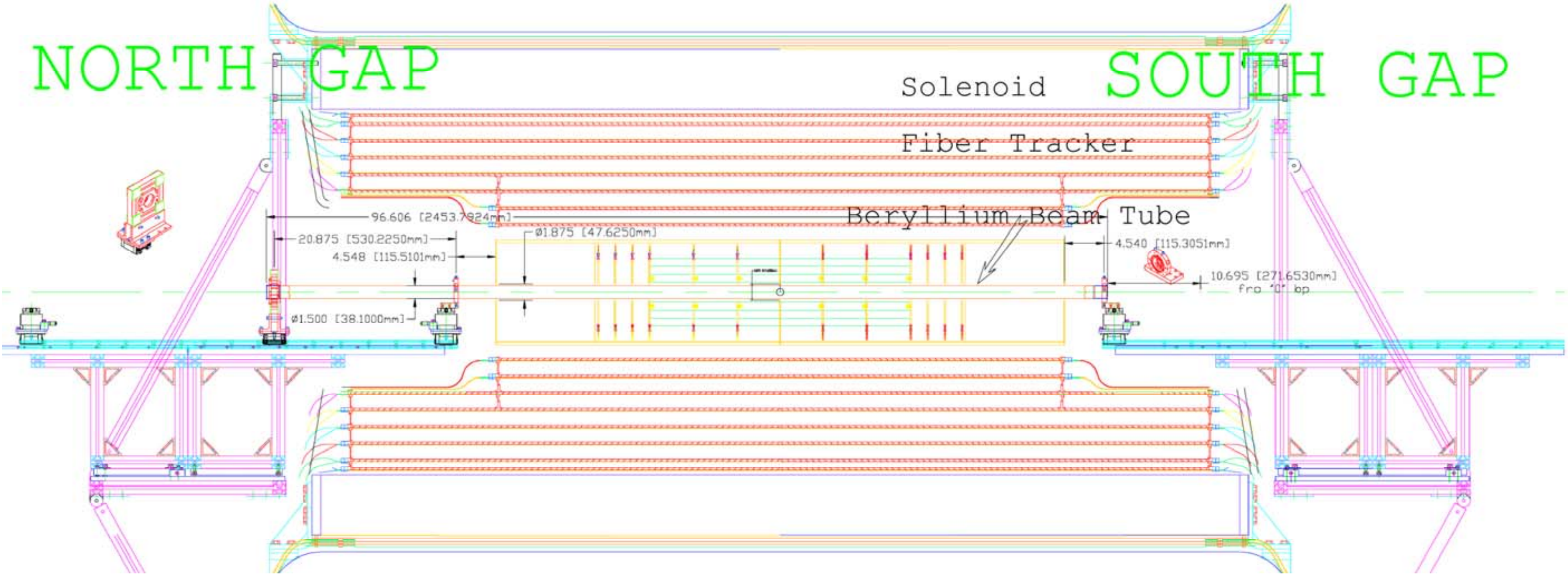
6. Close EC's. Temporarily lock in EC beam pipe axial location to the EC collar. Close EF's. Remove compressible beam pipe spools. Remove long tool from south EC beam pipe. Install outer beam pipe sections. Leak check beam pipe assembly. Activate SNEGS. Open EF. Remove temporary lock from EC pipes. Install BLM's.

7. Close CF's, Close EF's. Install VETO counters. Extend shielding. Magnet power test.



Run IIa Beam Pipe Removal (1)

- Beam pipe removal fixturing is based on that for L0 insertion.
- Clamps to hold the beam pipe are supported from stages on rails.
- The beam pipe will be extracted towards the north.

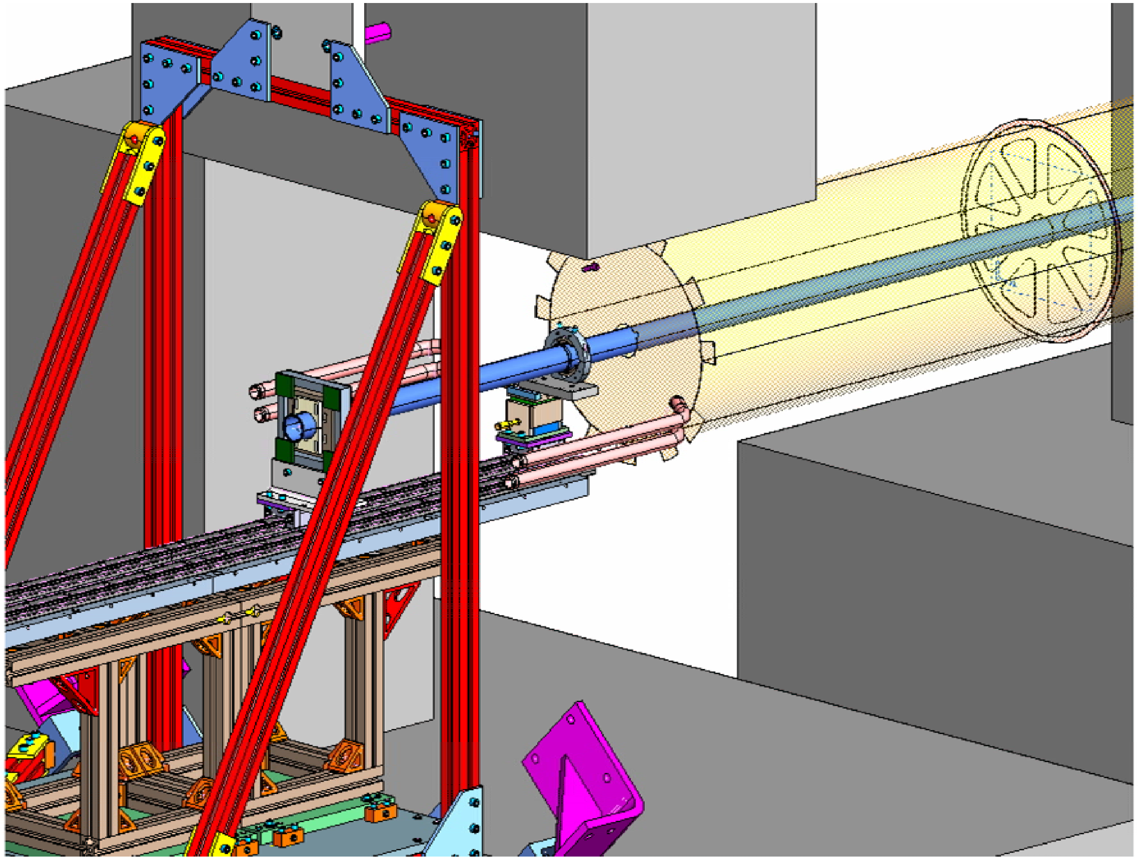


- Beam pipe flange radius = 21.59 mm (0.43 mm less than L0 design radius)

Fixtures designed by Youri Orlov

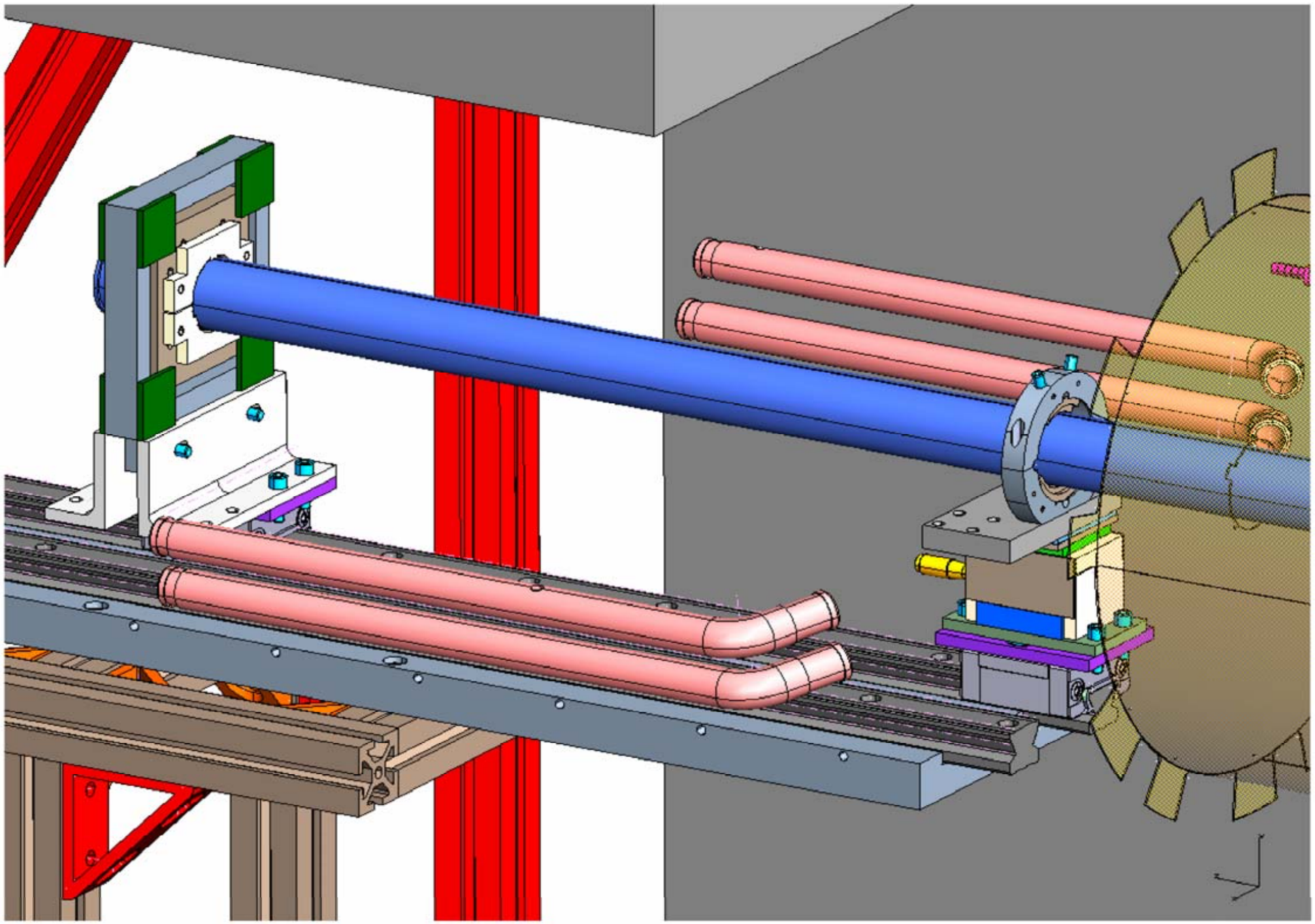
Run IIa Beam Pipe Removal (2)

- The outer clamp shown at the north end is designed to exert sufficient downward force to cantilever the beam pipe once the pipe is no longer be supported from the south.
- A third clamp at the north allows support points to be shifted.



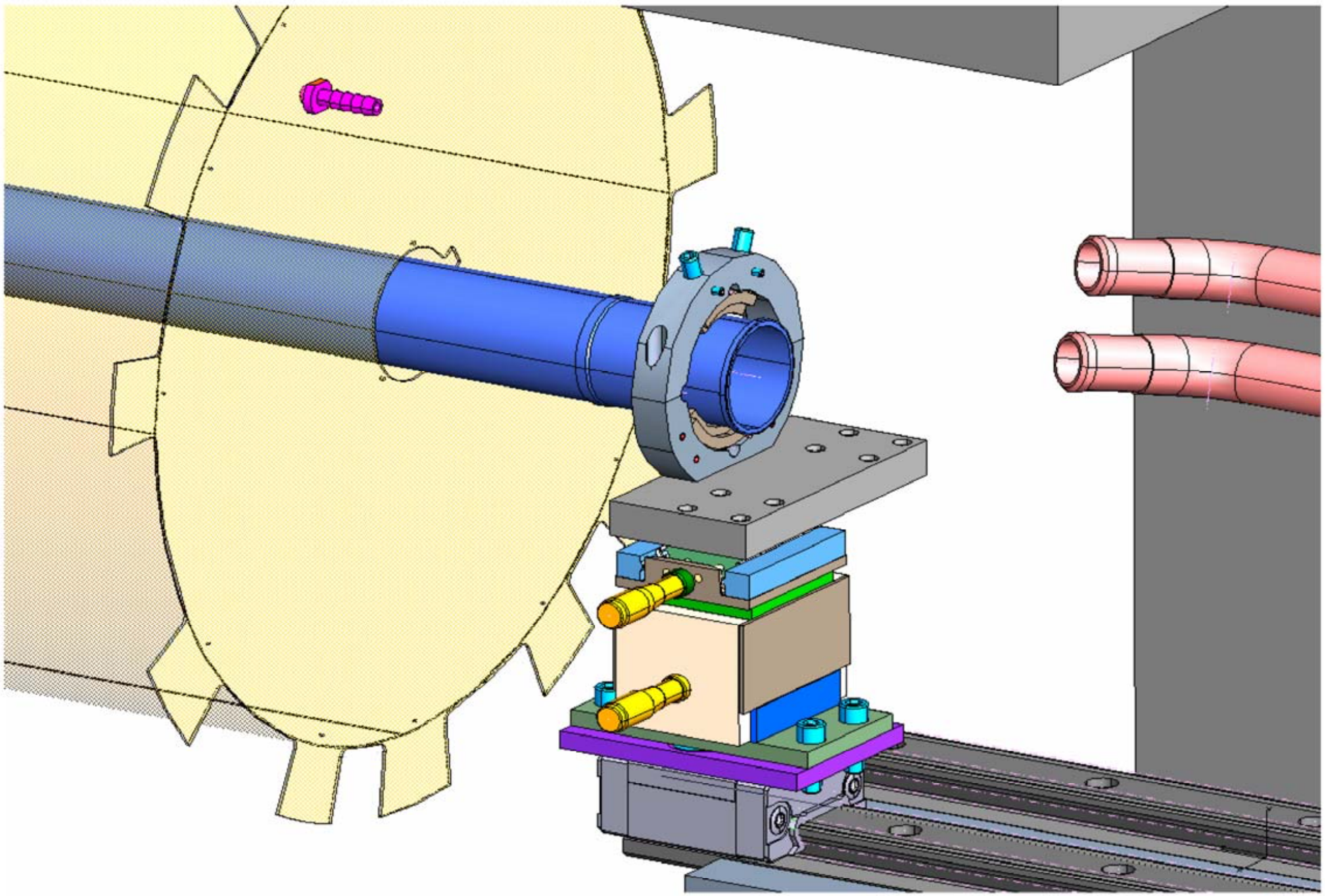
Run IIa Beam Pipe Removal (3)

- North end clamp, stage, and rail details



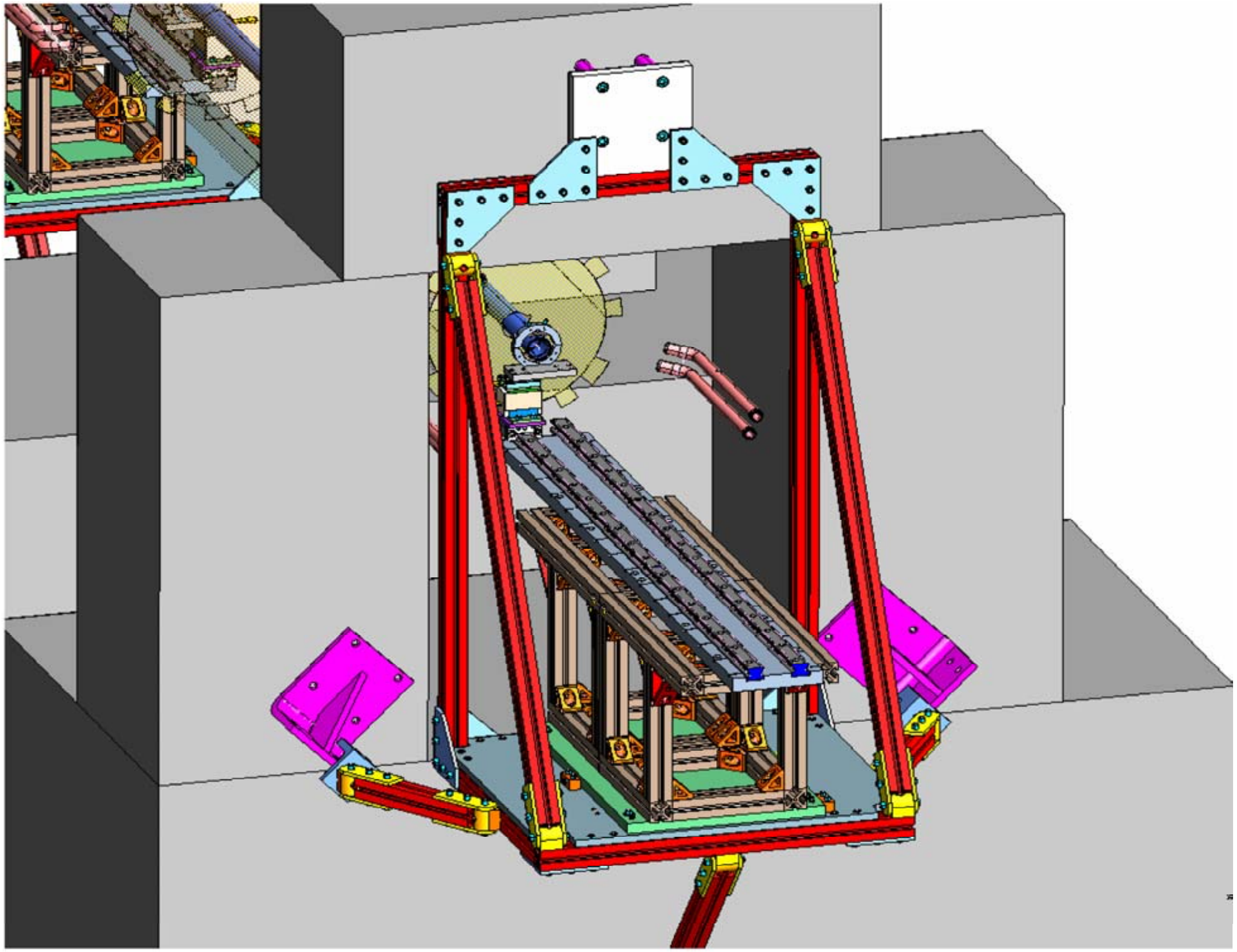
Run IIa Beam Pipe Removal (4)

- South end clamp, stage, and rail details



Run IIa Beam Pipe Removal (5)

- South end at limit of south fixturing travel (beginning of cantilevered support)

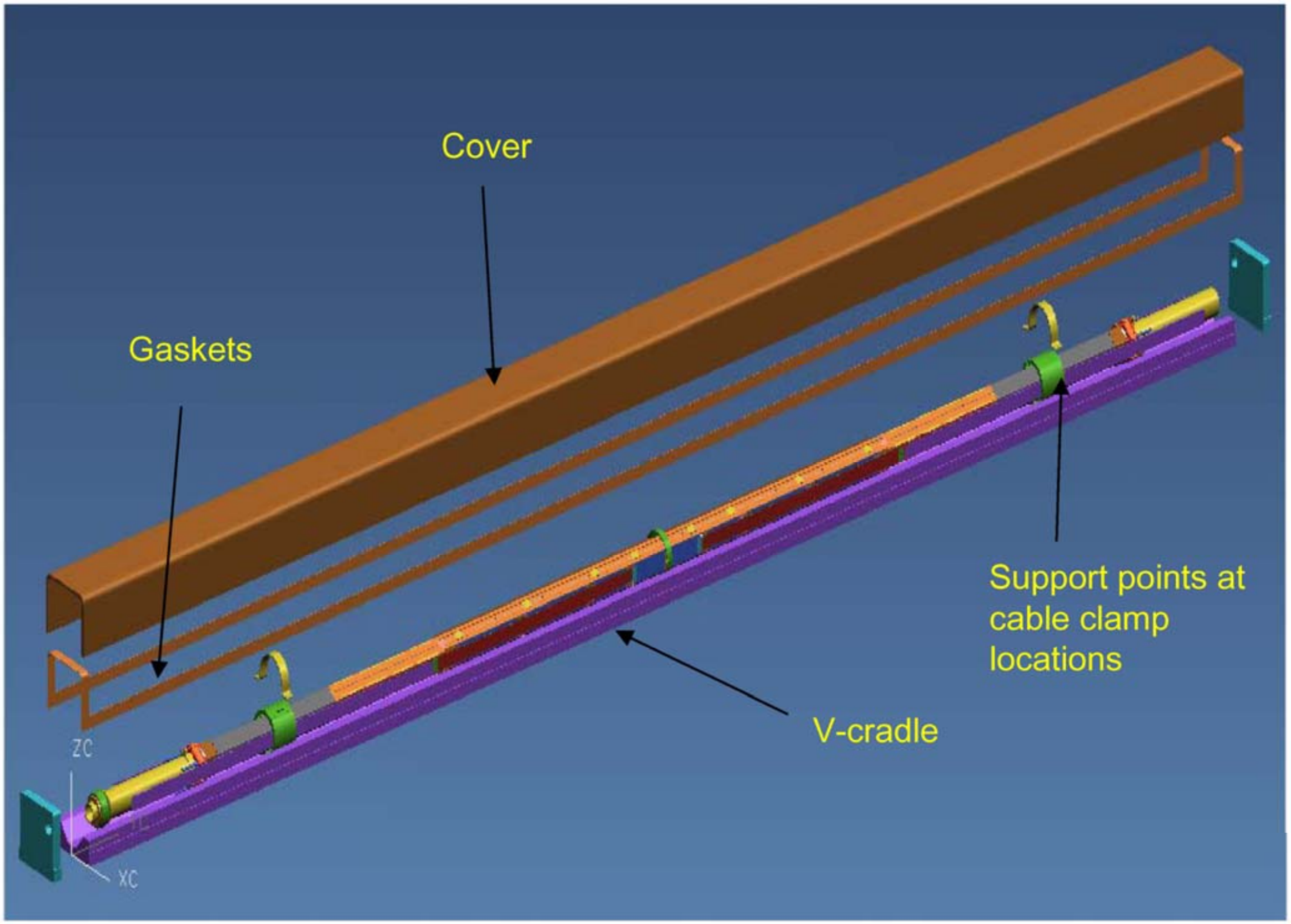


Initial L0 Installation Steps

- Intermediate tools are installed on the ends of L0 at SiDet.
- Cables are dressed on them.
- The L0 assembly is placed into a transport container (with dry gas purge) and an outer wooden box, then moved to DAB.
- At DAB, the transport container and L0 are moved to the outer end of ECN (combination of moves on a cart, short moves by hand, and a controlled lift).
- L0 is extracted from the transport container and brought through the ECN beam pipe aperture.
- L0 mounts have already been installed on the end membranes of the Run IIa silicon support structures.
- Support tables are in place in CC – EC gaps.
- A “long tool”, which aids in L0 installation, has been threaded through the Run IIa silicon aperture.
- Further steps are described as part of the Lab 3 installation test.

L0 Transport Container

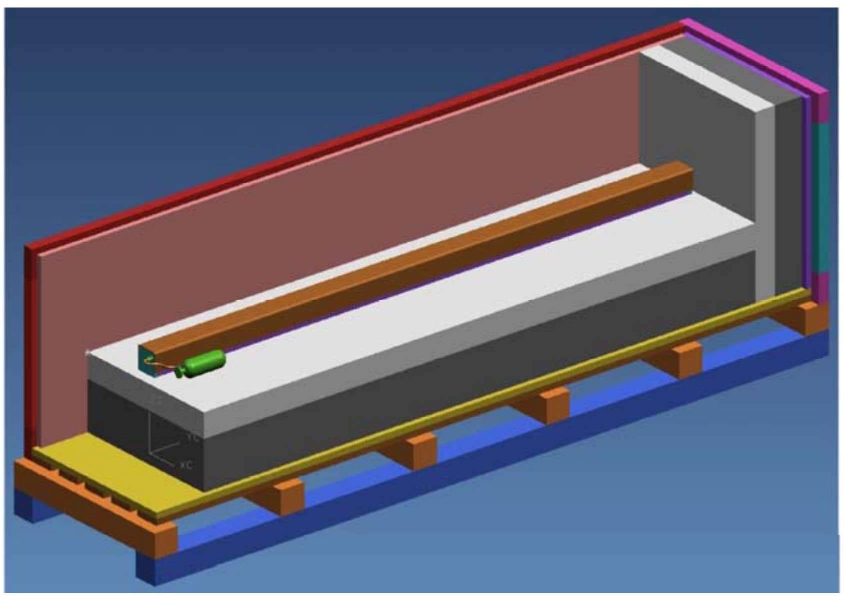
- Both a prototype and a final container are complete and here.



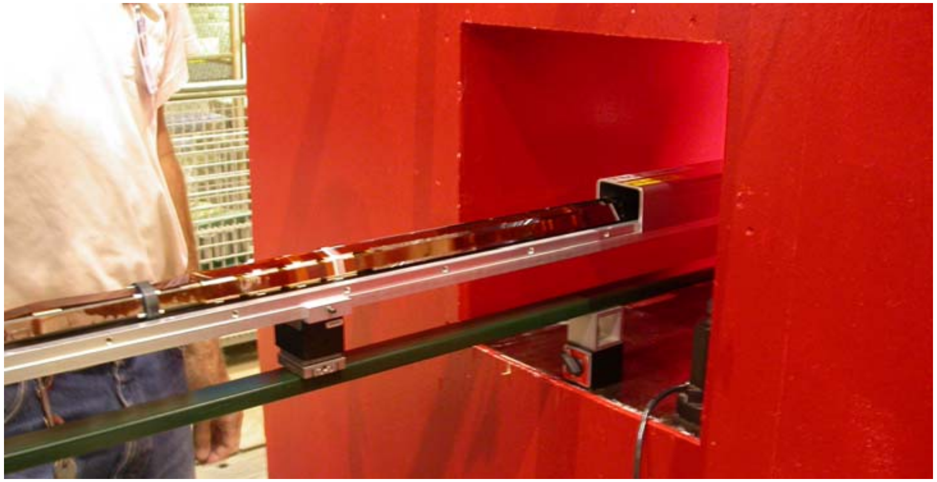
Transport container from U. Washington

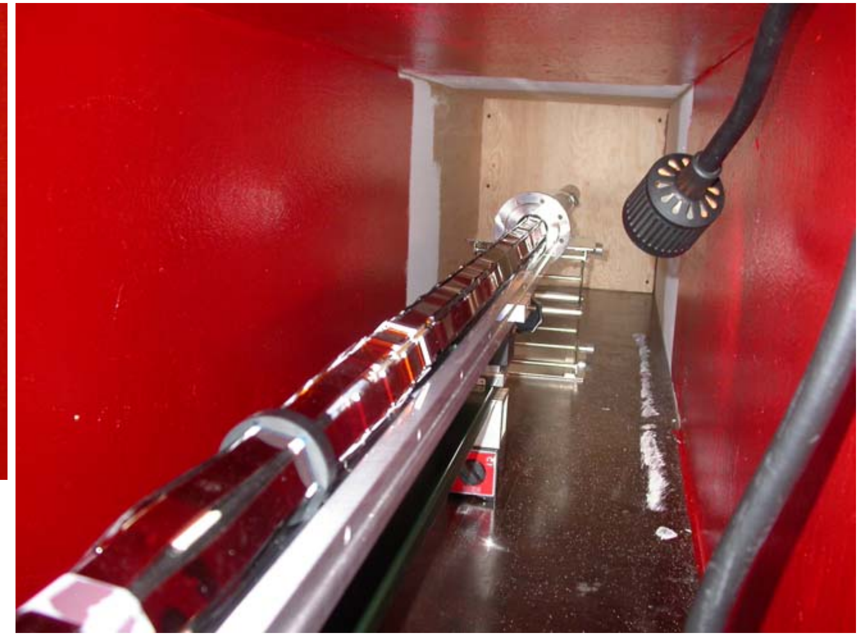
L0 Transport Box

- The transport container fits within a padded outer box. The box in which the transport container was shipped to Fermilab could be used.



DAB Tests of L0 Insertion into EC Beam Pipe



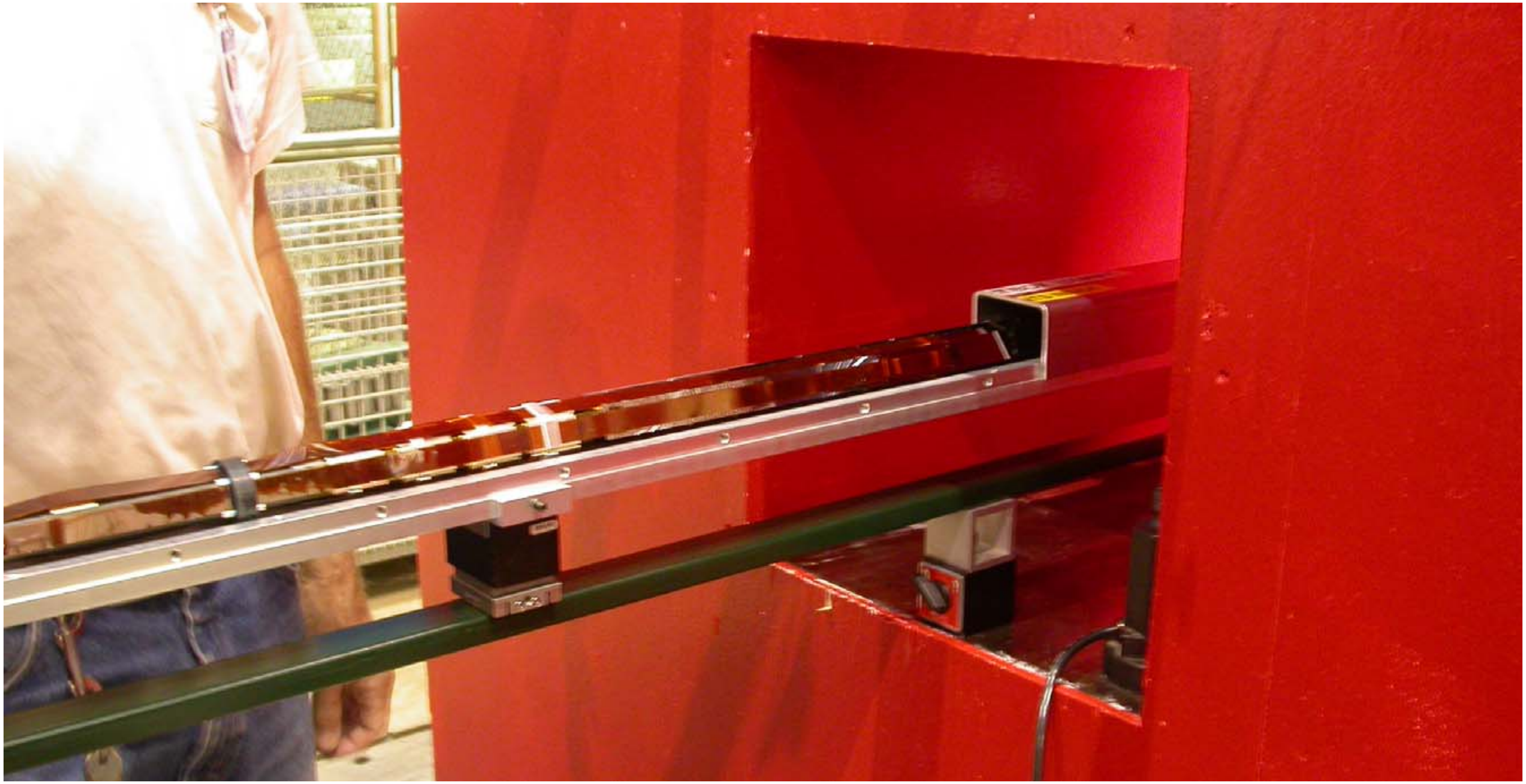


- Mock insertions of L0 into the EC calorimeter beam pipe were successful.
- Russ Rucinski supervised fabrication of a mock-up of the region outside ECN. UW provided the L0 transport case.
- A dummy case will be used to align fixturing supported from shielding.
- The real case, with L0 within, will replace the dummy.
- Case covers will be removed.
- L0 will be guided by a V-channel of the case and inserted into the beam pipe.

L0 Insertion Tests at DAB

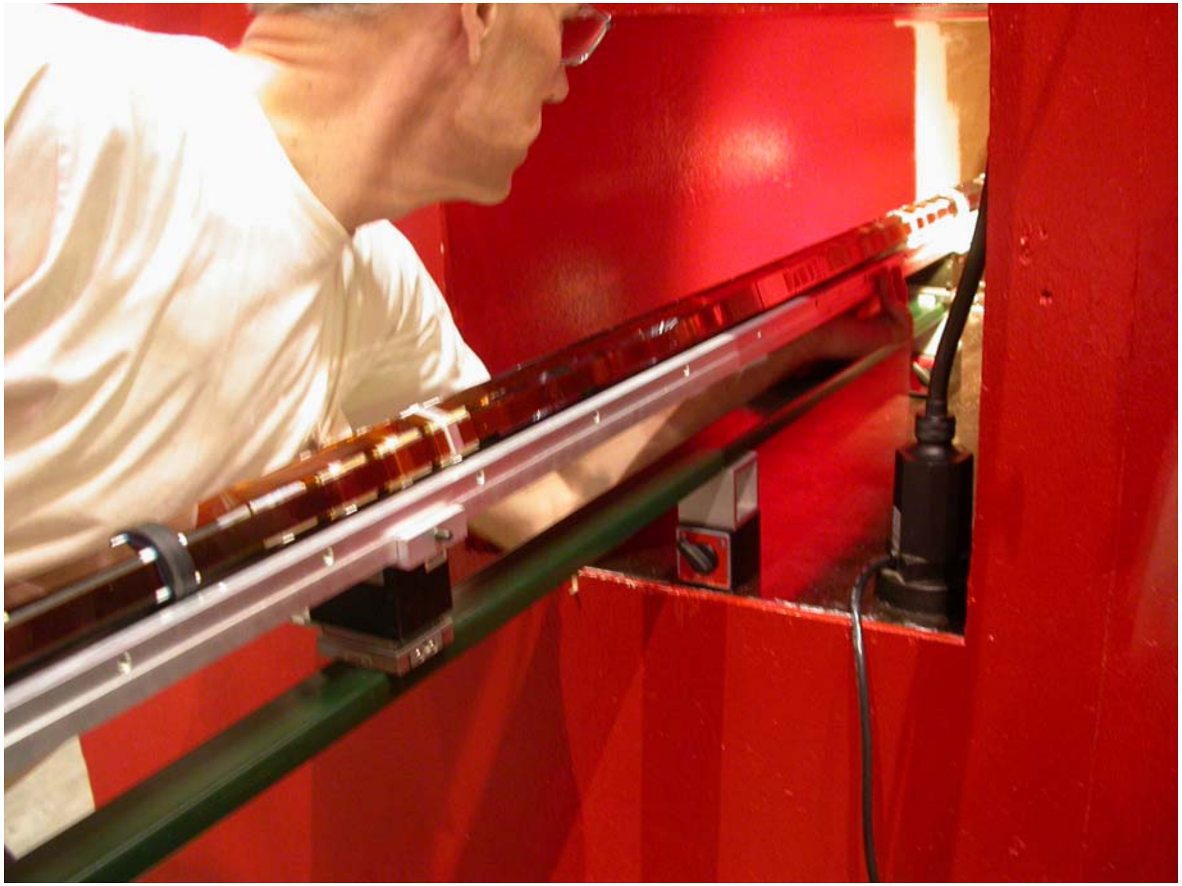
- The picture above shows the transport case being moved into position within the shield iron aperture.

L0 Insertion Tests at DAB



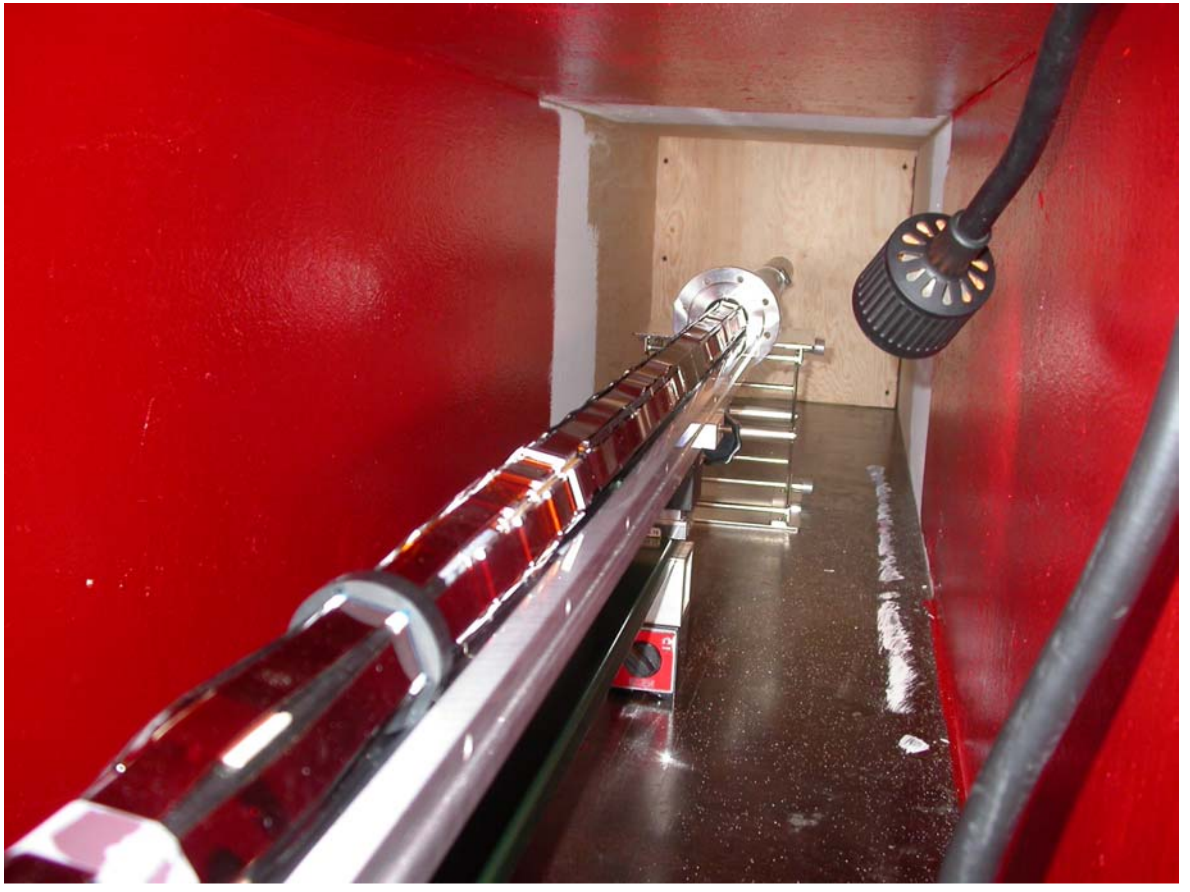
- The top cover of the transport case is divided into two longitudinal sections. In this picture, the outer section has been removed.

L0 Insertion Tests at DAB



- Both top covers have been removed.

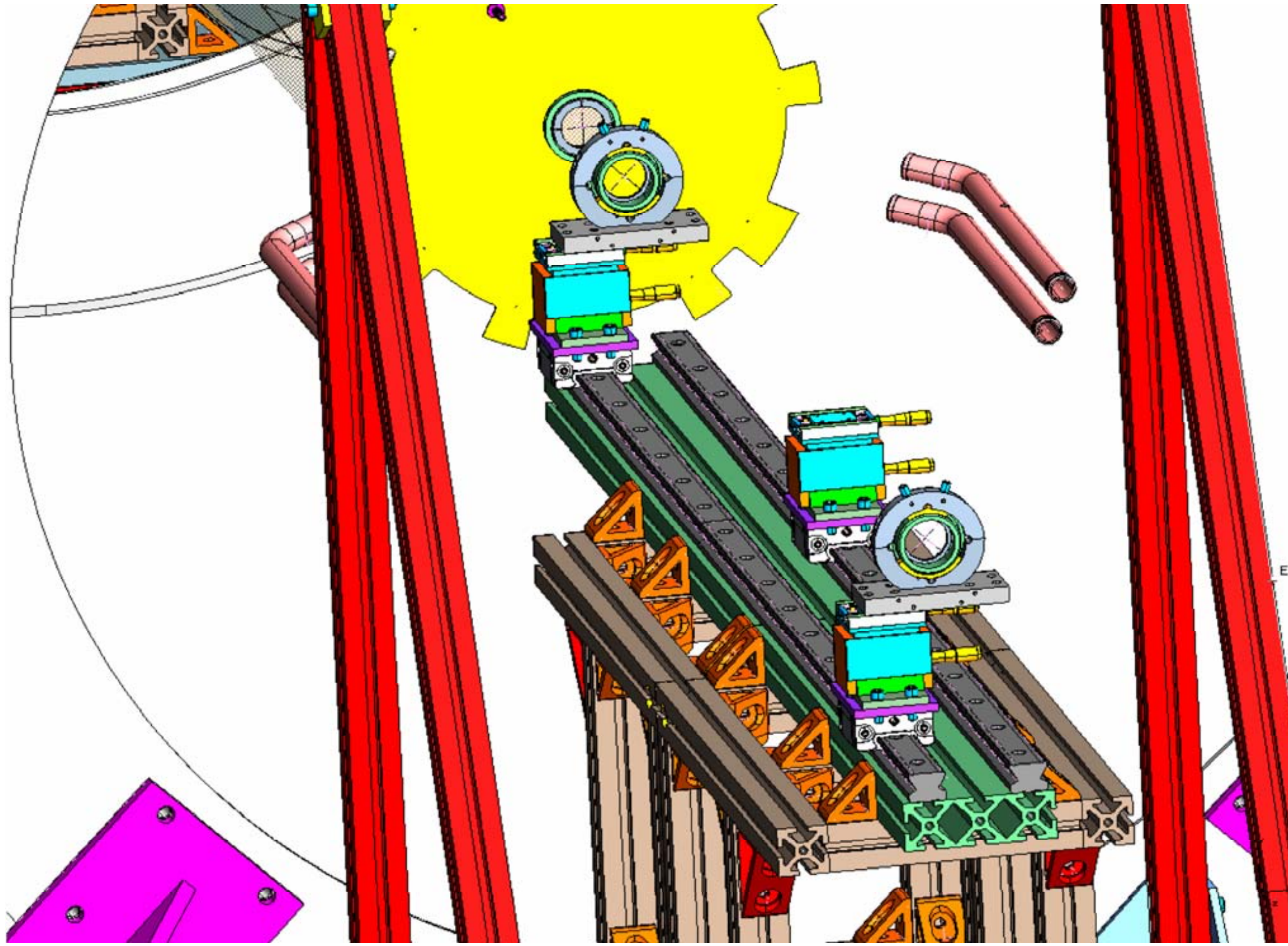
L0 Insertion Tests at DAB



- L0 has been partially inserted into the beam pipe aperture.
- The mock L0 was brought the full length of the beam pipe.

Installation of L0 Mounts (1)

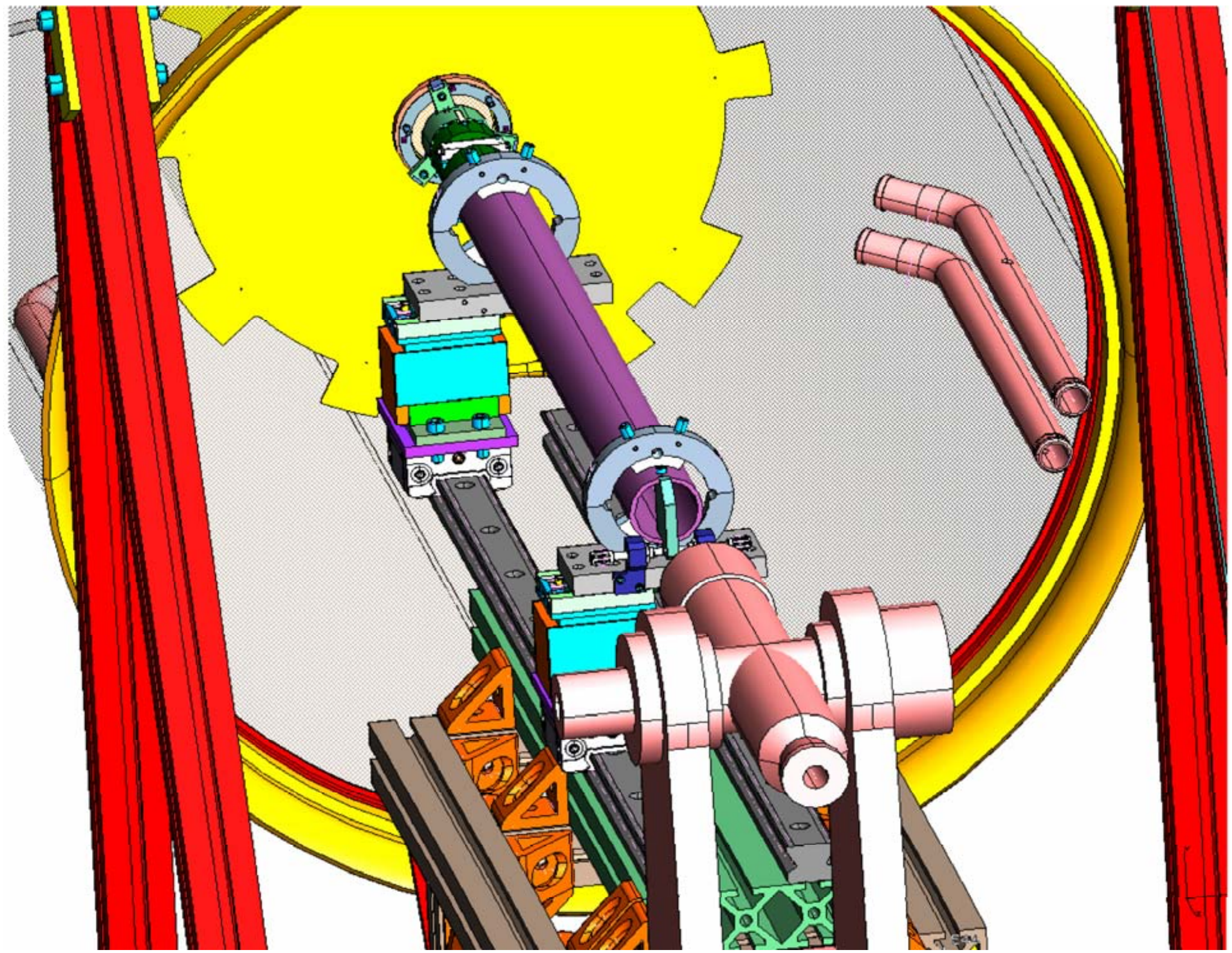
- Tooling is similar to that used for L0 insertion.
- The Brunson line of sight is centered on cross-hairs inserts placed into the two outer membrane openings.
- Installation tooling holders are aligned on that same line of sight.



Figures from Youri Orlov

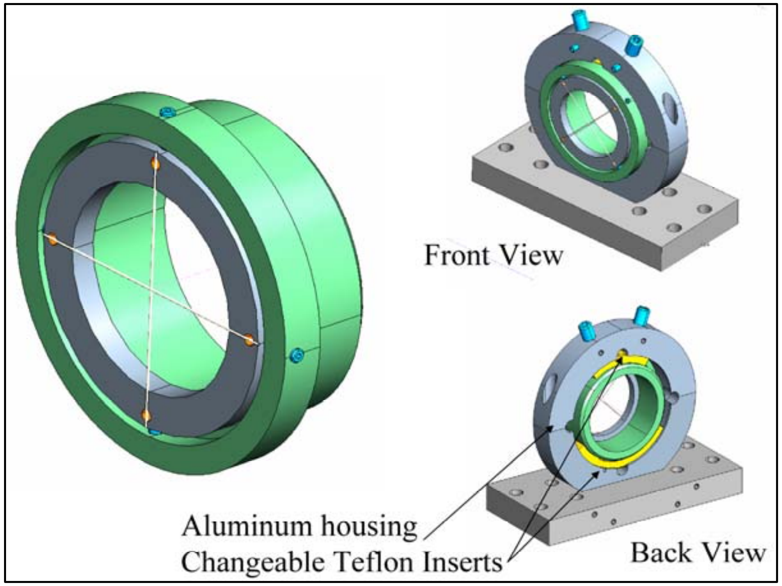
Installation of L0 Mounts (2)

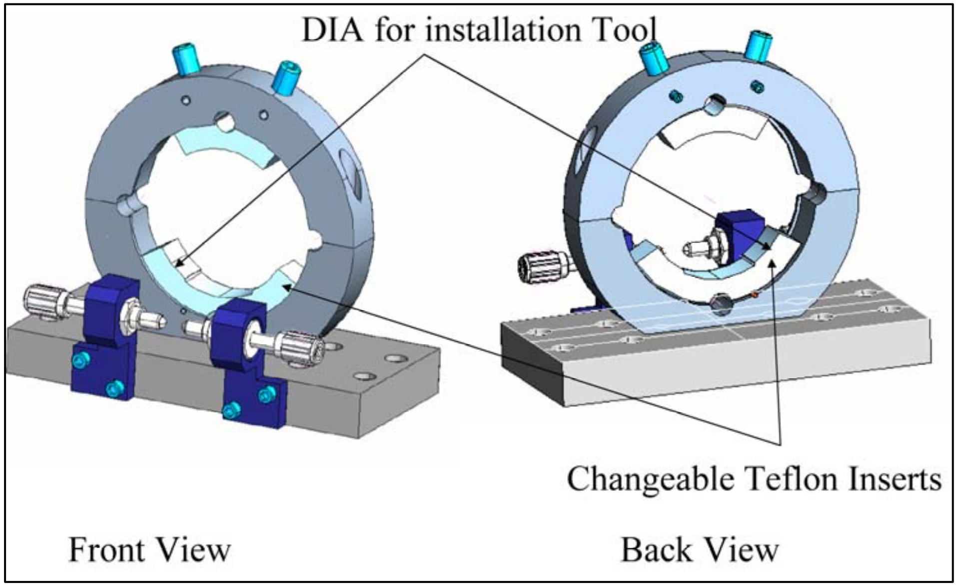
- A cylindrical tool replaces cross-hairs and holds the L0 mounts as they are glued into place.
- Each mount ring carries fiducials.
- The Brunson guides placement of fiducials at the desired transverse coordinates.
- An electronic level is used to set azimuthal orientation.



Installation of L0 Mounts (3)

- Holders can carry either cross-hairs or the cylindrical tool.
- Tool alignment need only be good enough to provide a sufficiently uniform glue thickness.
  - The mount fiducials and Brunson set mount transverse position.
- Clamps will be added to maintain the mount position as glue cures.
- This procedure will be tested in Lab 3.

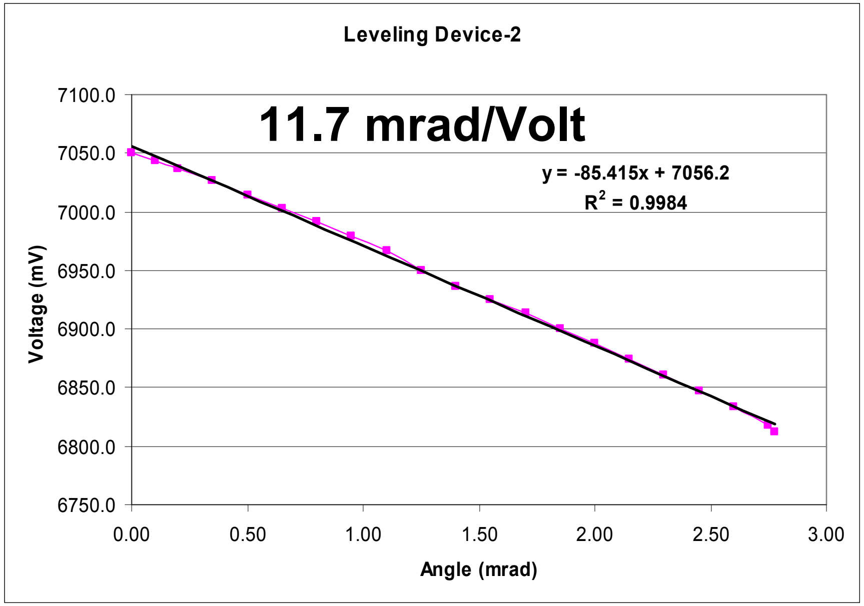




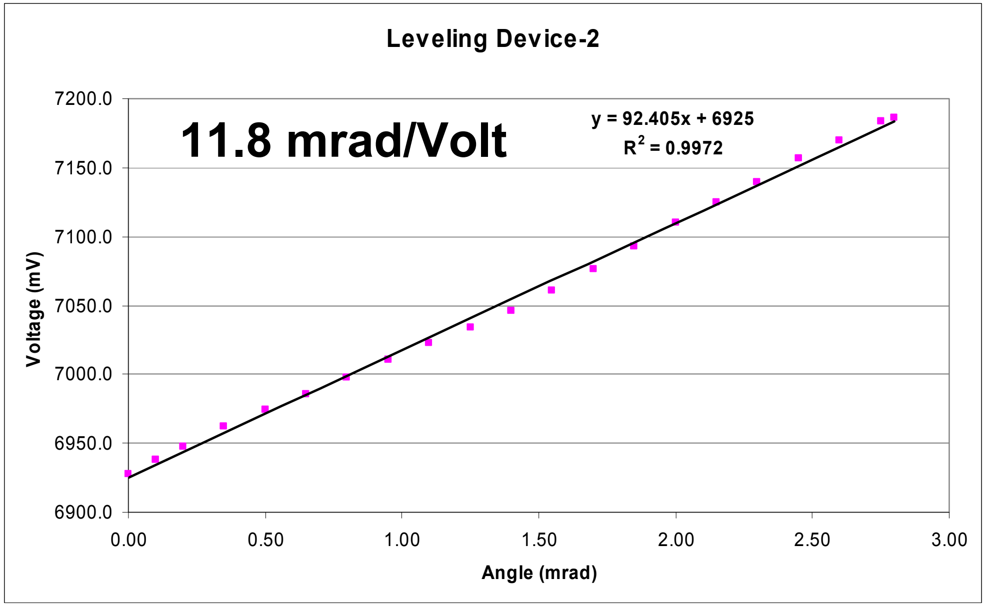
Installation of L0 Mounts (4)

- Three electronic levels have been assembled and tested by Selcuk Cihangir.
  - One device borrowed from AD; two devices bought for D0
- All perform similarly. Calibration results for device 2 are below.
- Desired precision is ~ 0.3 milliradians or ~ 26 millivolts.

First measurement



Second measurement



Location of **EZ-TILT-3000**

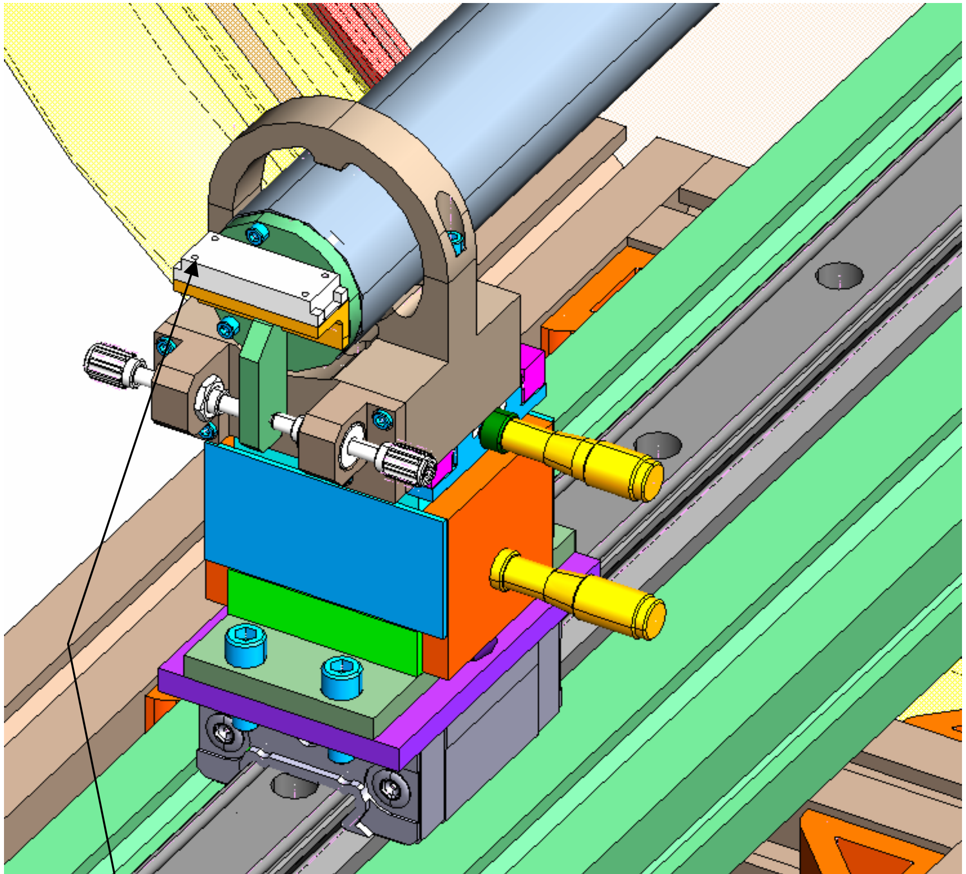
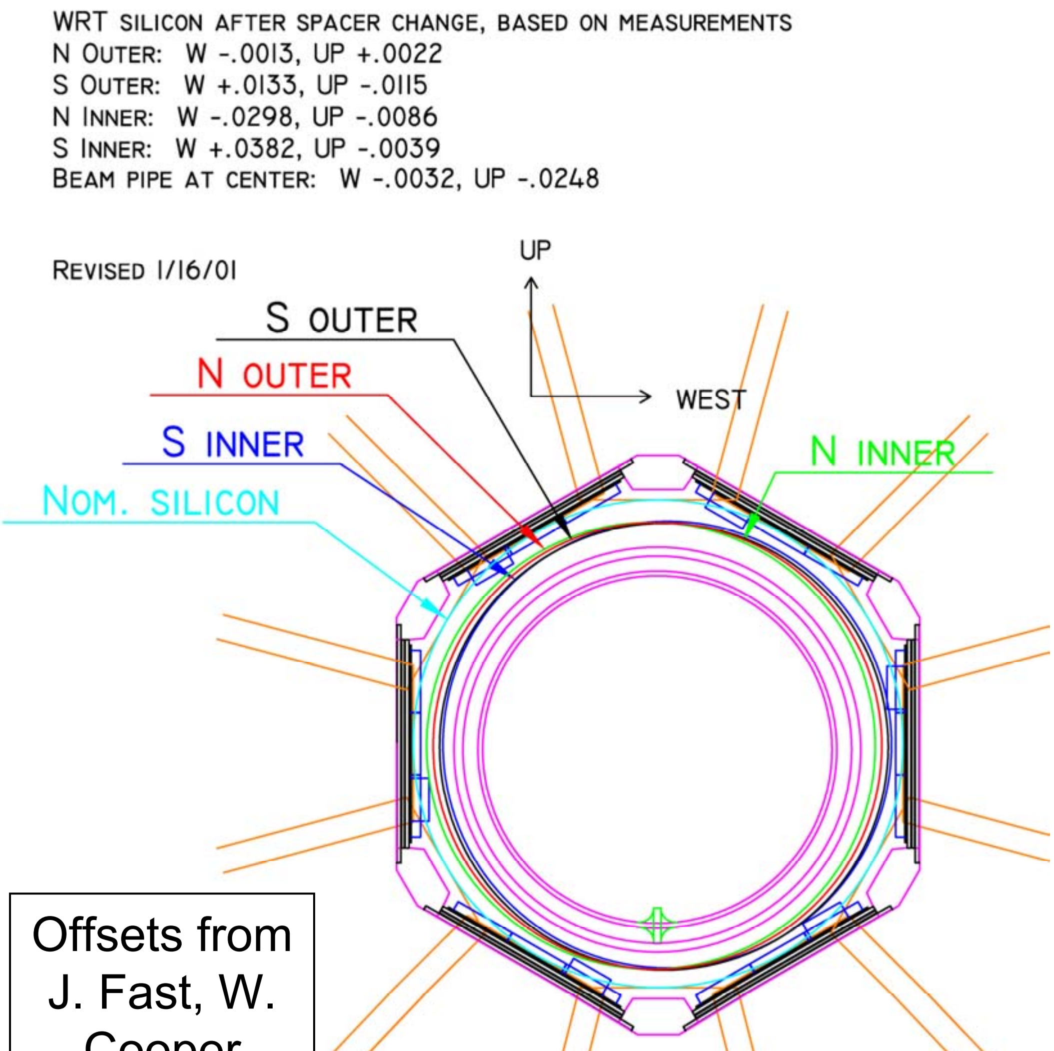


Figure from Selcuk Cihangir

High Precision Leveling Module EZ-TILT-3000
By Advanced Orientation Systems, Inc.

L0 Transverse Alignment

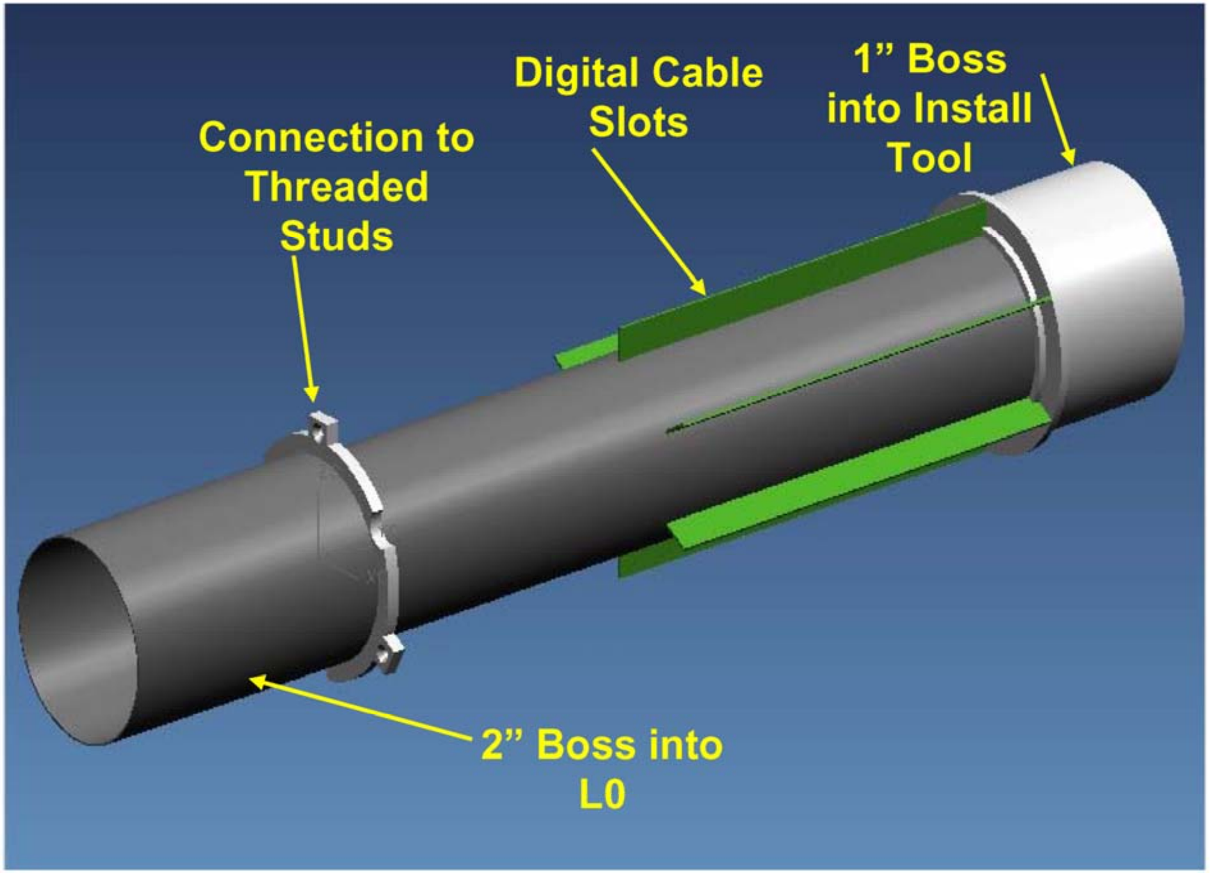


Offsets from J. Fast, W. Cooper

- Analysis is done, but should be checked.
- Positions of membrane openings relative to Run IIa silicon centerline are shown at the left (units = inches).
  - Based upon CMM measurements at SiDet and Lab 3
  - Outer membranes will be used to position Layer 0
  - North
    - **x = -0.001”, y = +0.002”**
  - South
    - **x = +0.013”, y = -0.012”**

L0 Intermediate Installation Tools

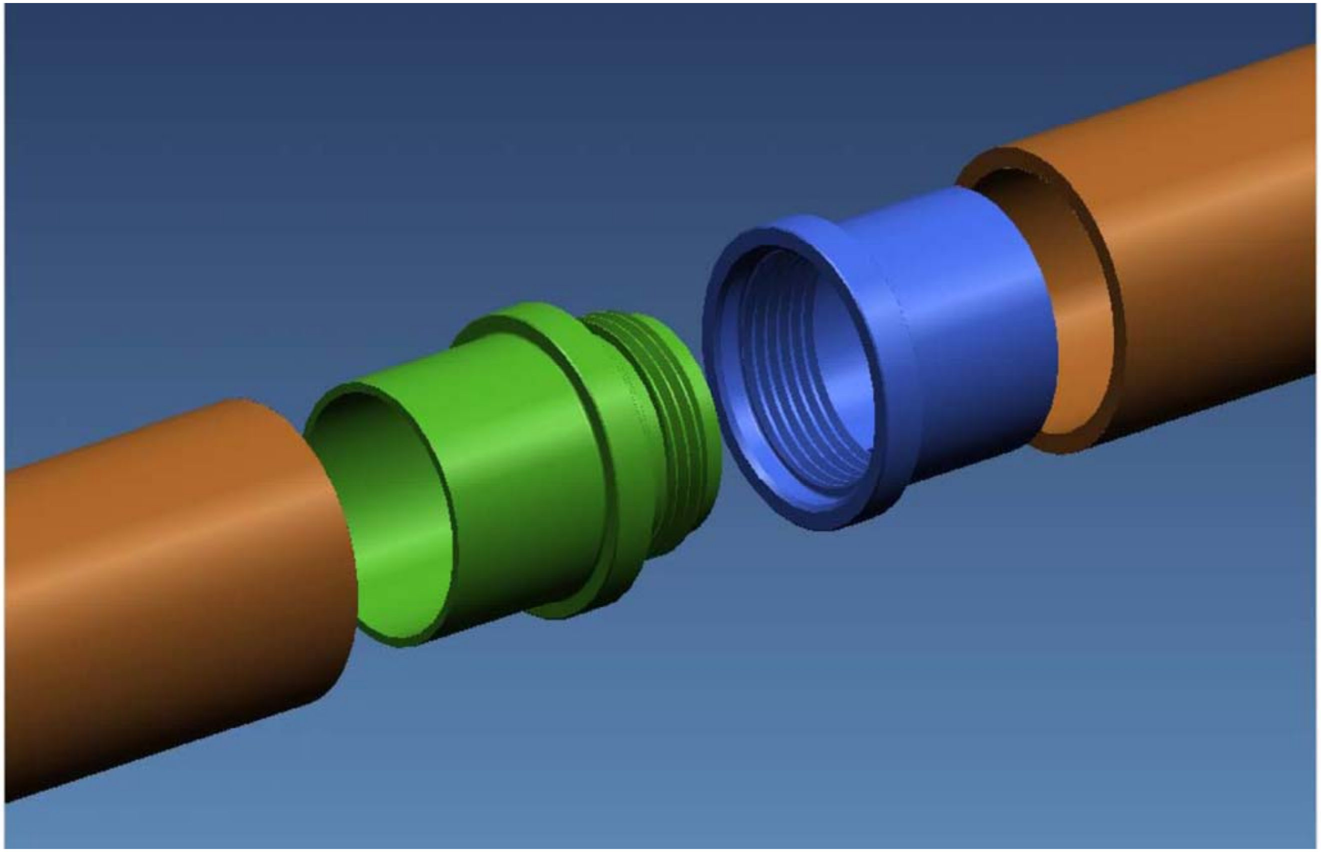
- Intermediate tools allow cables to be dressed for L0 installation and connect ends of L0 to the long or short tool. Fins to guide cables are not needed and were omitted.



Long, short, and intermediate tools made by U. Washington

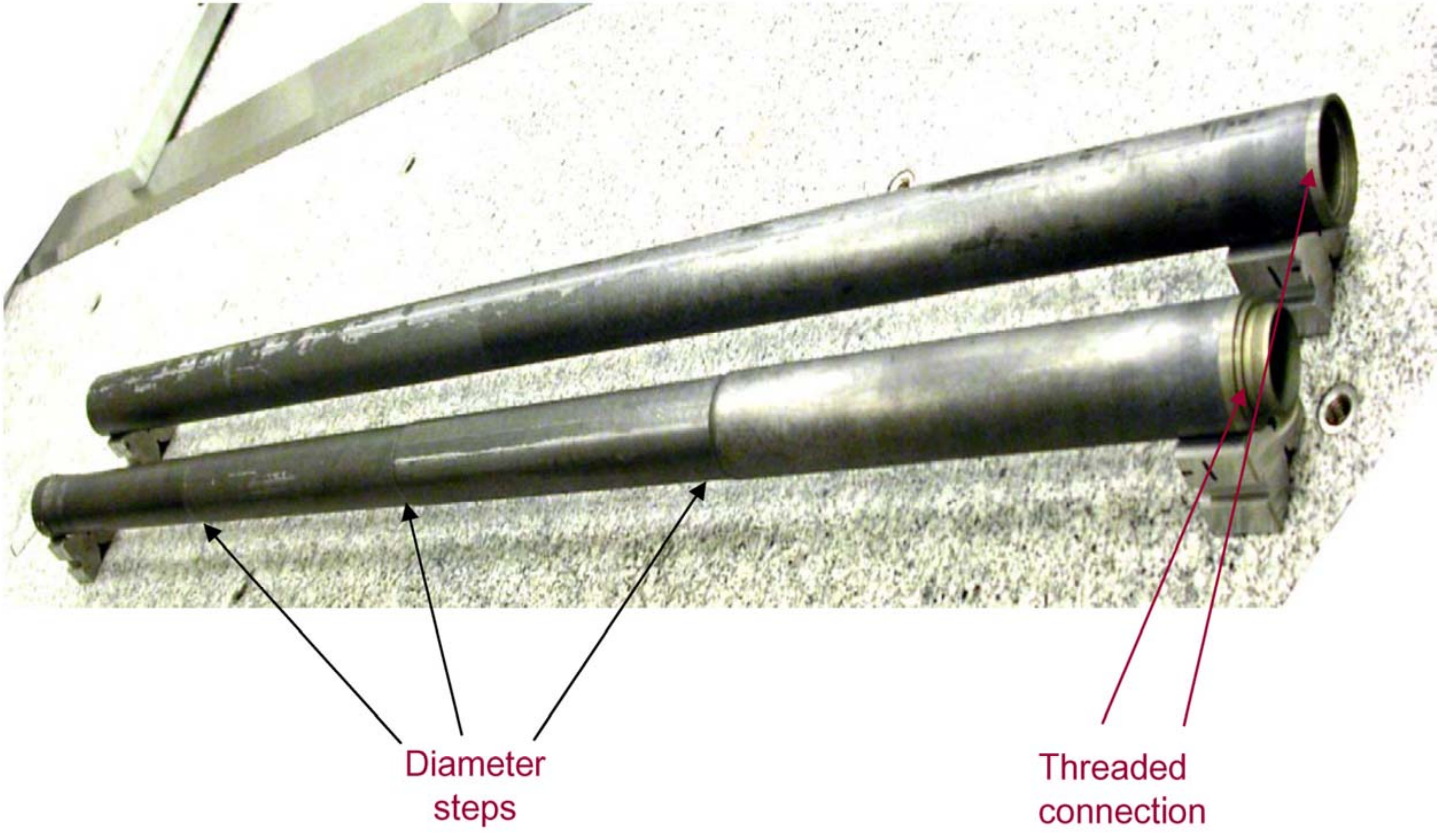
L0 Long Installation Tool

- A threaded joint allows the 96” long tool to be brought into place without passing through ECS. That reduces the number of detector moves needed during installation.



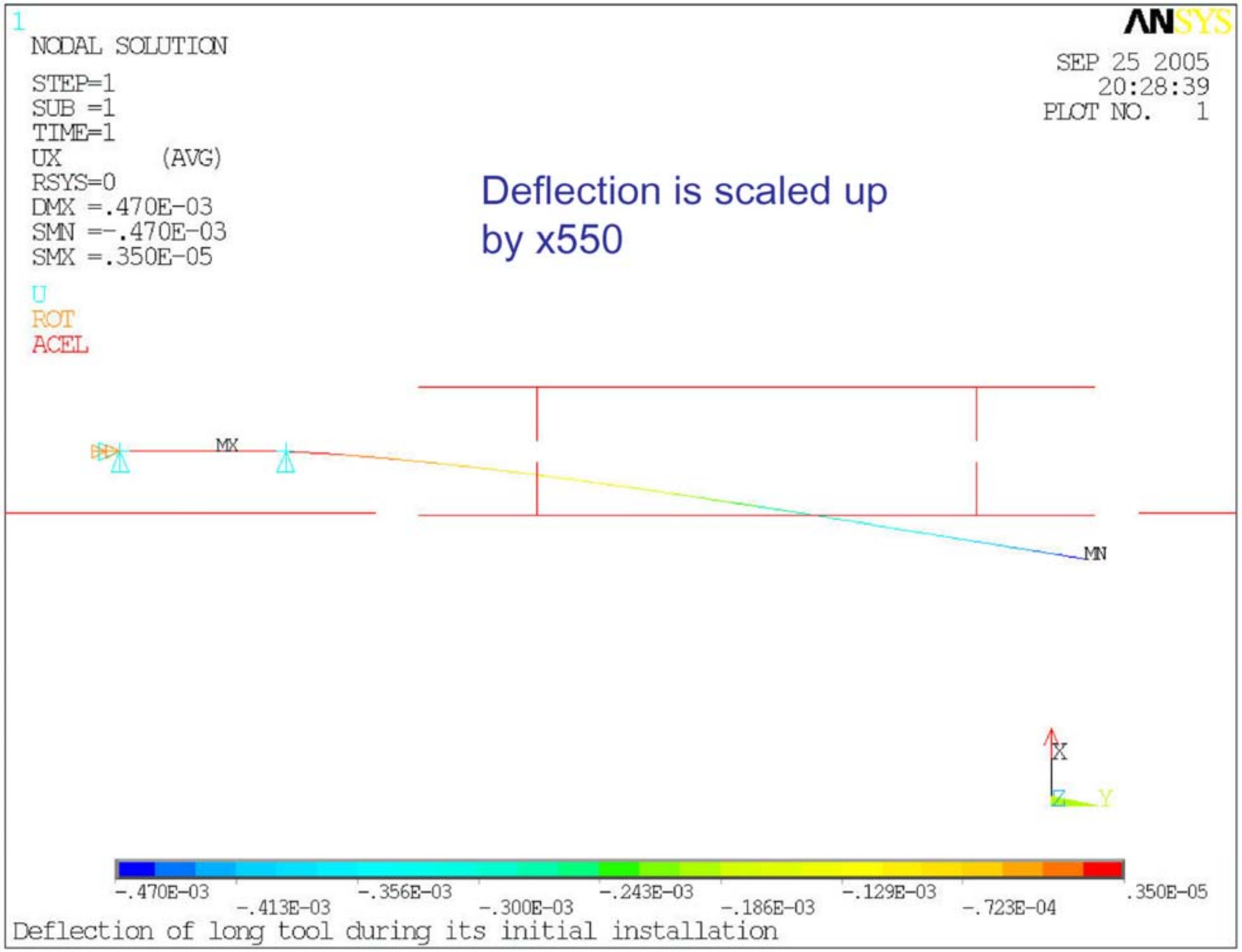
L0 Long Installation Tool

- Two pieces of the long tool



L0 Long Installation Tool

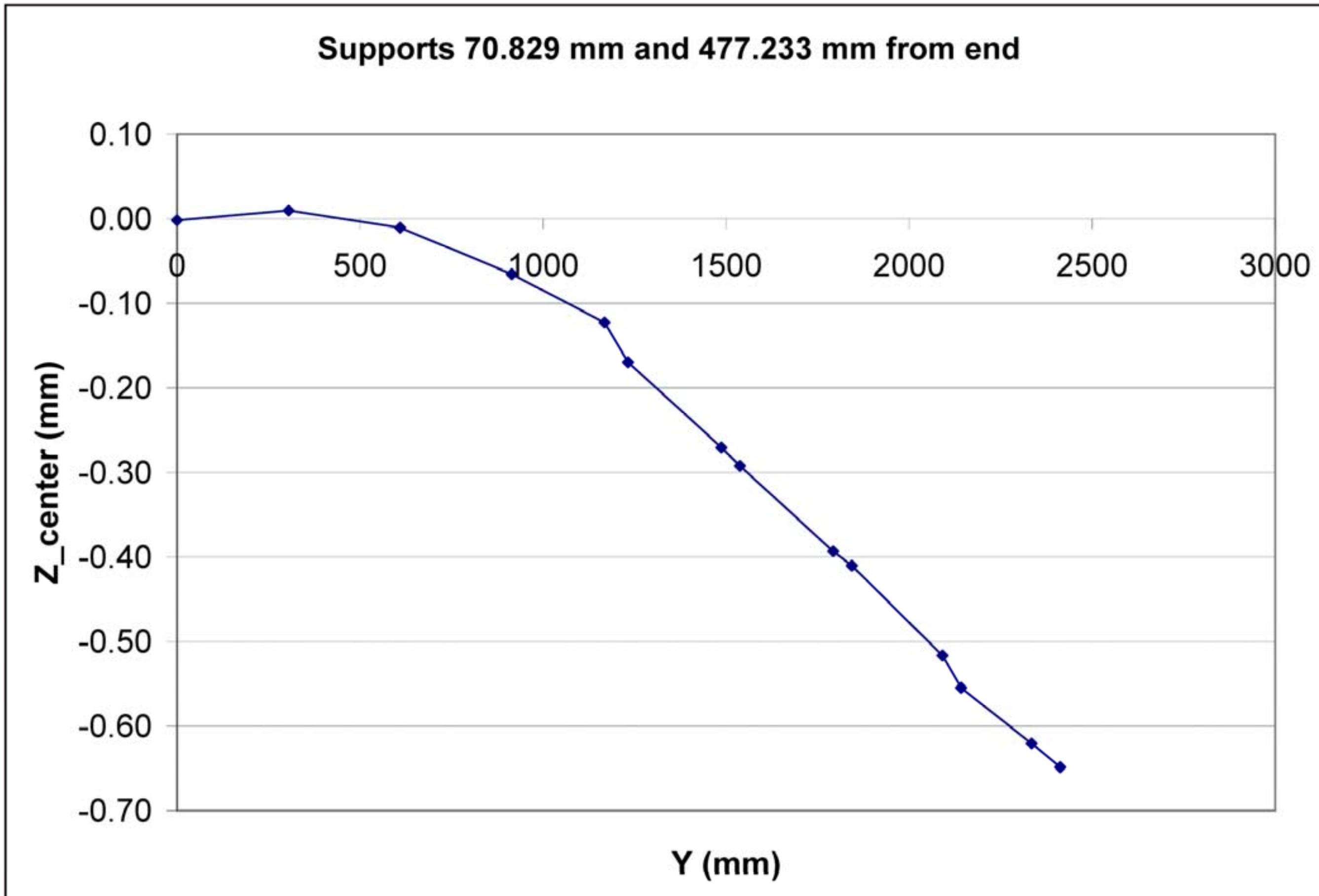
- Deflection of the long tool as it is cantilevered during insertion is 0.47 mm.



FEA by Colin Daly (U. Washington)

SiDet CMM Measurements of Long Tool

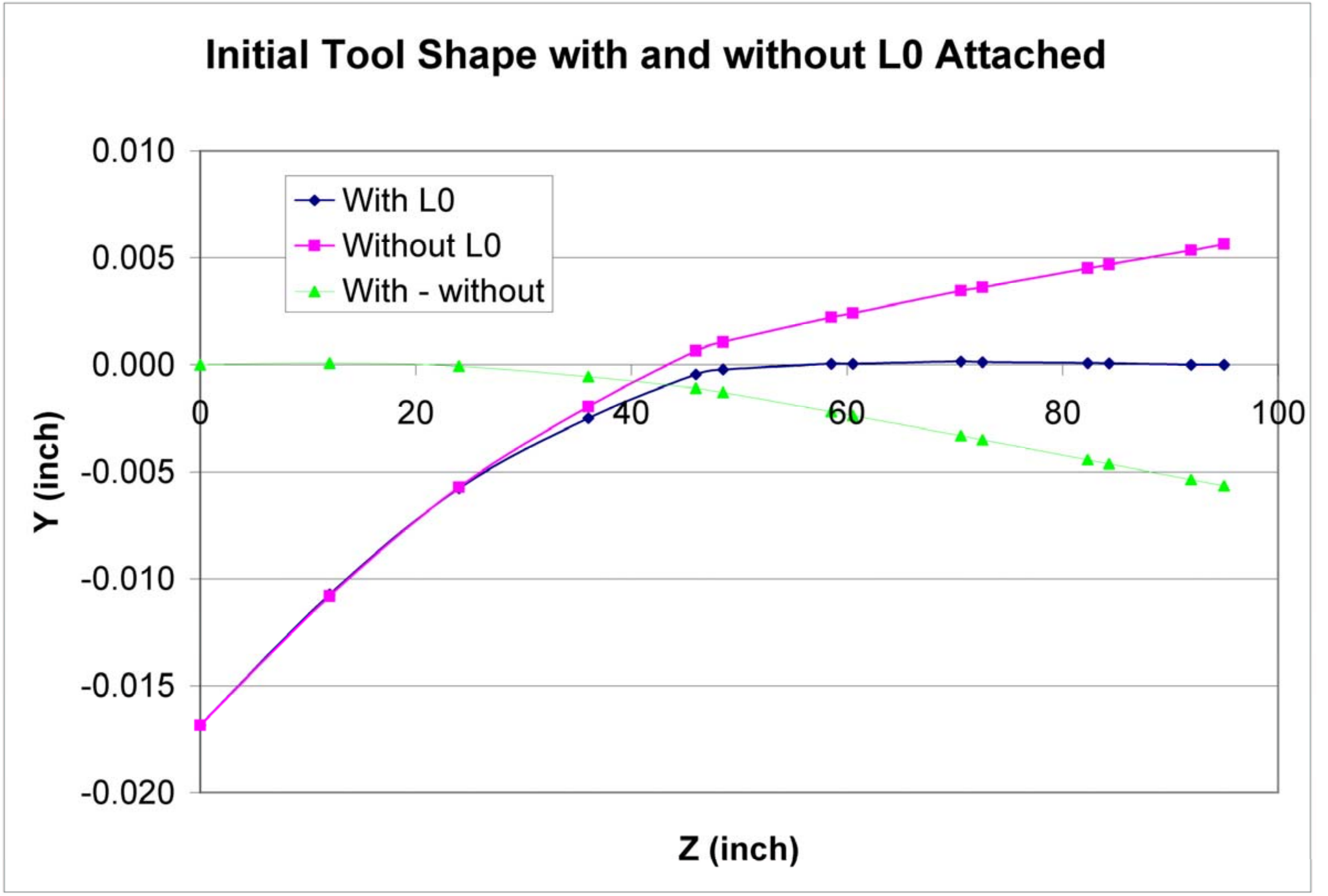
- Support points of FEA and this measurement were different. If compensation were made for the difference, CMM data would predict a deflection of 0.54 mm, in reasonable agreement with FEA.



Z is up and Y is along the tool length.

Long Tool Deflection

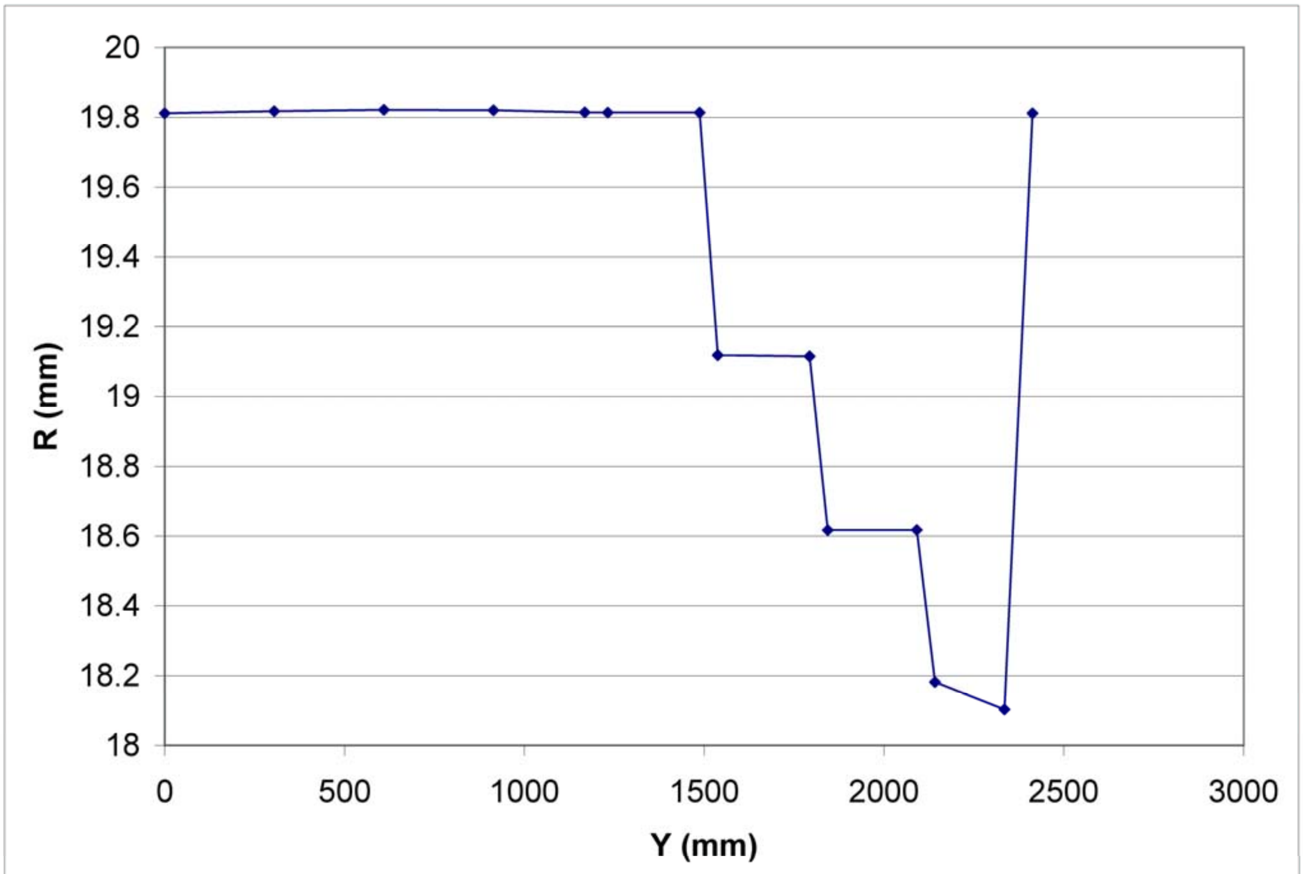
- Lab 3 tests assumed deflections based on fits to the CMM data.



In this plot, Y is up and Z is along the tool length.

SiDet CMM Measurements of Long Tool

- Roundness was good. Radial steps reduce weight and cantilevered deflection. The tool radius increased at the connection to the intermediate tool (point at Y = 2440 mm).

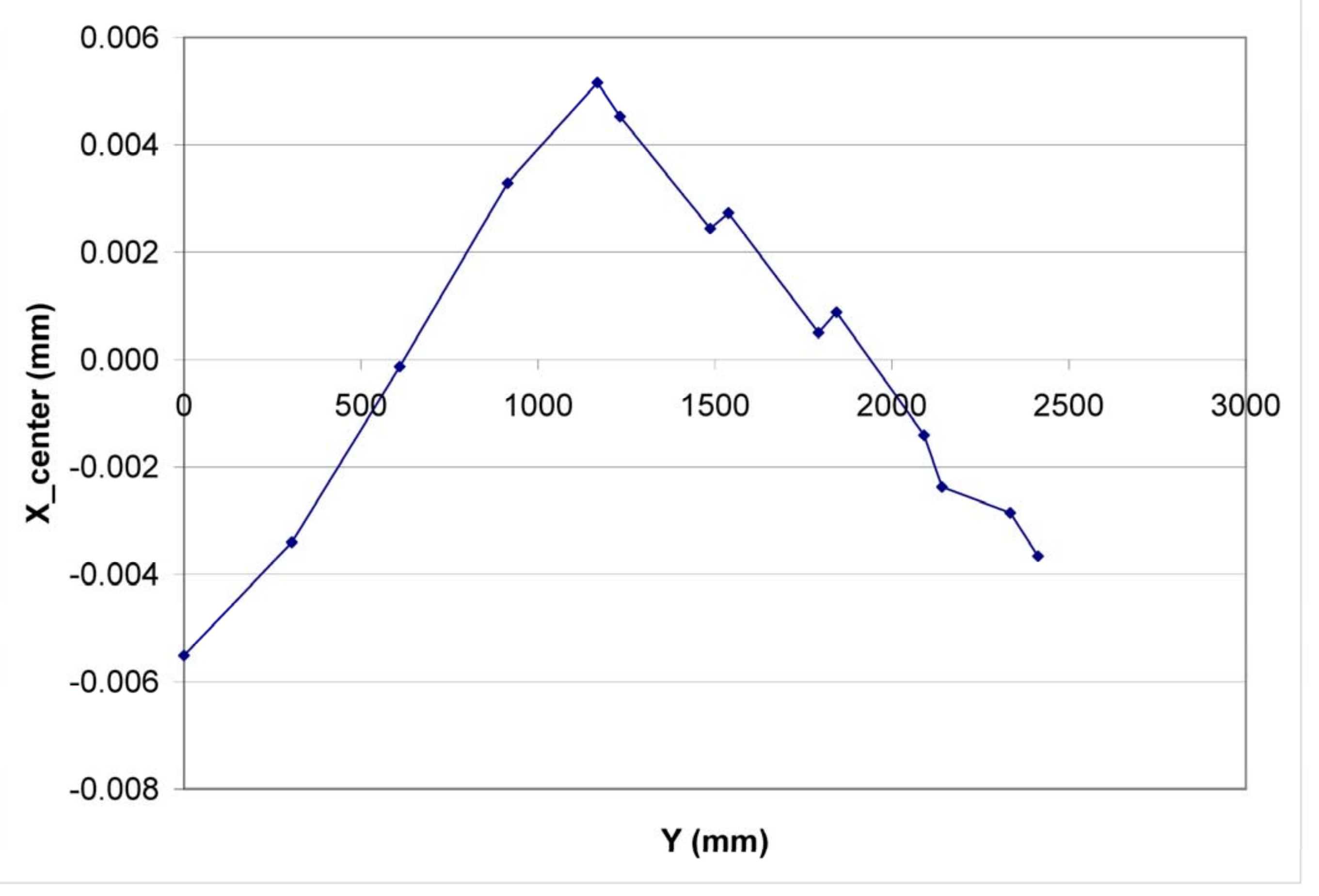


Y is along the tool length.

SiDet CMM Measurements of Long Tool

- The kink at the joint between the two tool sections gives a measure of reproducibility of the joint (~ 10 µm sagitta after multiple disconnections and reconnections) (negligible for L0 installation).

X is horizontal and Y is along the tool length.

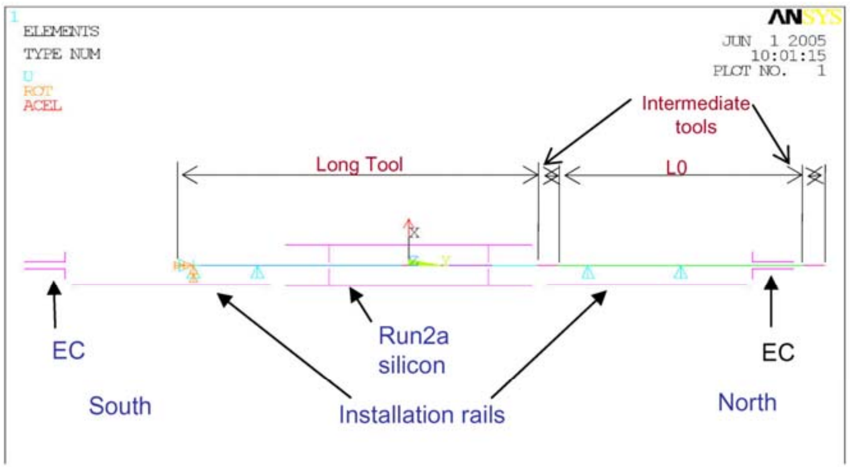


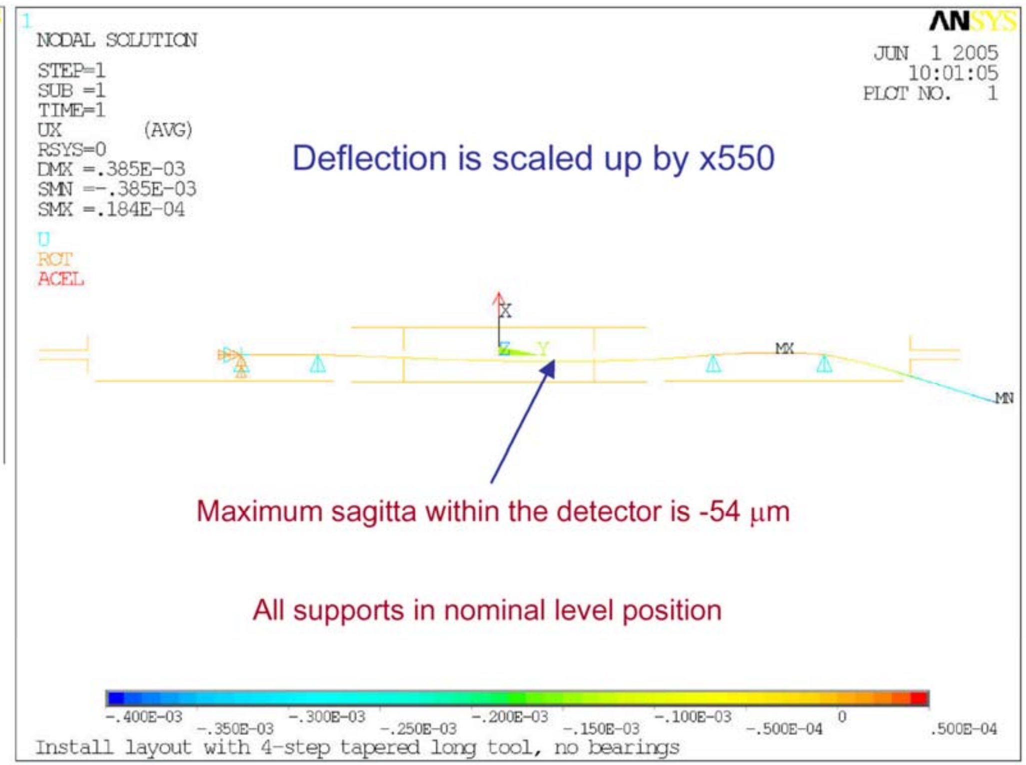
L0 Short Installation Tool

- The short tool to be used at the north end is made of two aluminum sections. We learned in Lab 3 installation tests that only one section is needed.

L0 Installation Deflections (1)

- South end of L0 connected to long tool with additional L0 support from carriages in the north gap.

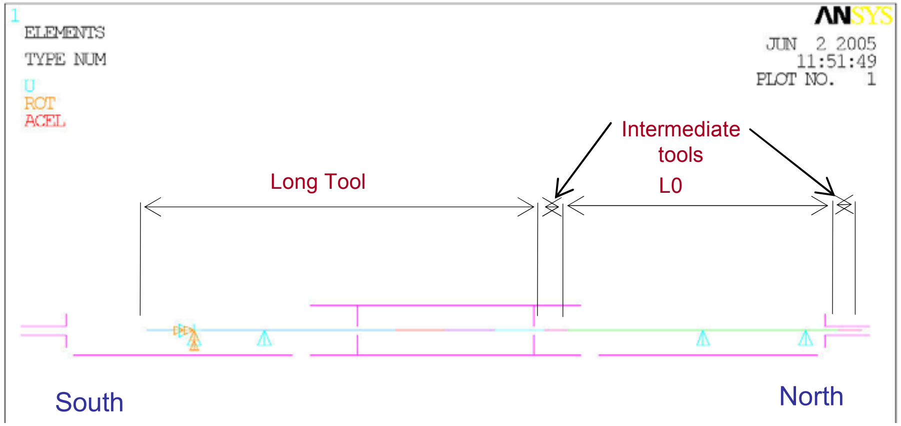


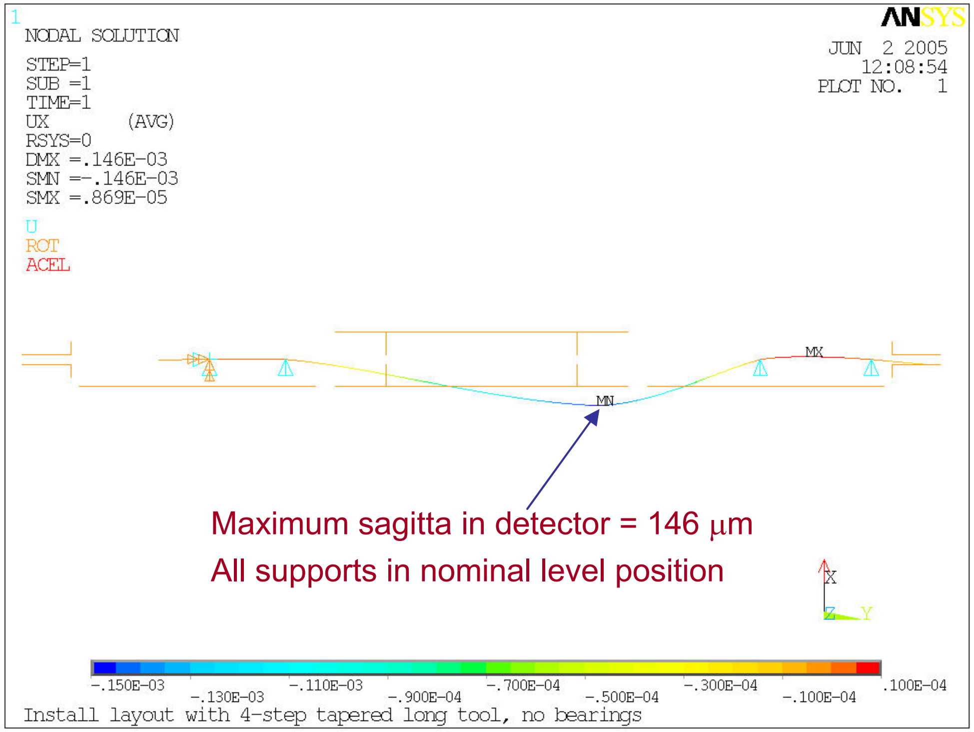


FEA by Colin Daly
(U. Washington)

L0 Installation Deflections (2)

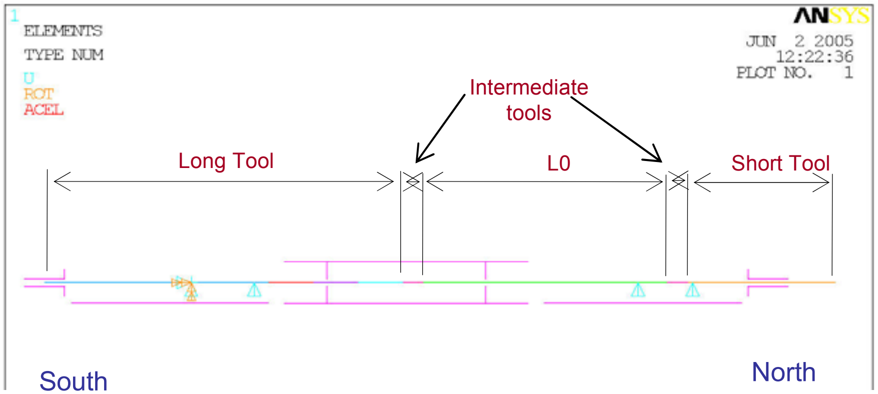
- After sliding L0 260 mm south and re-gripping the long tool

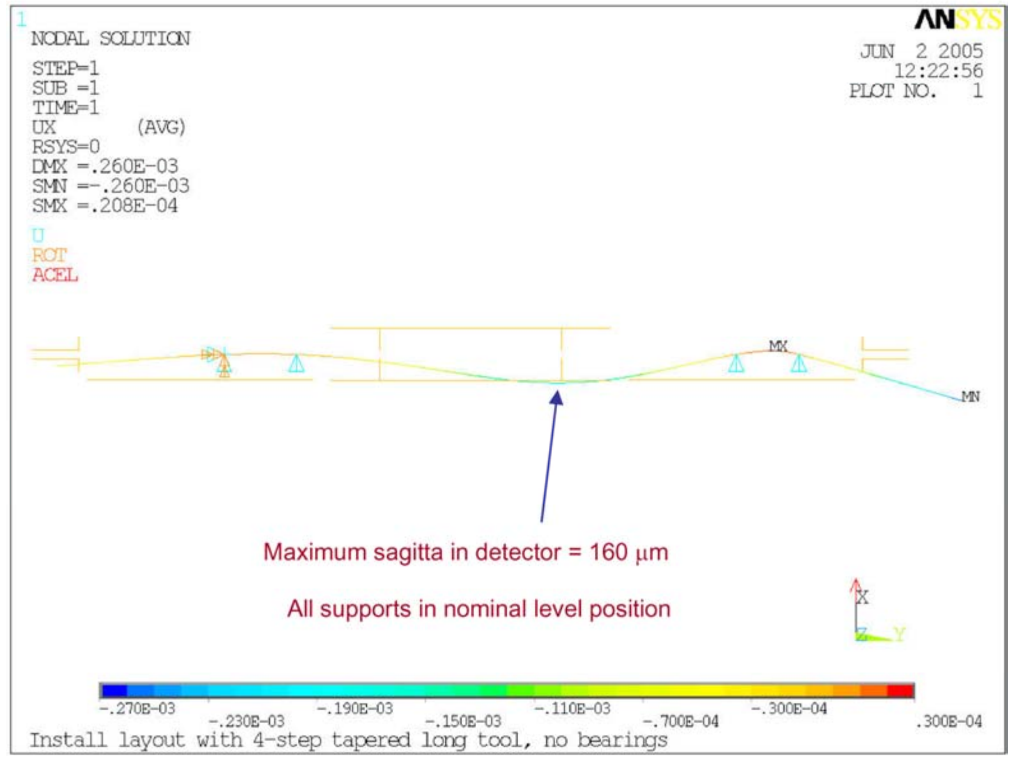




L0 Installation Deflections (3)

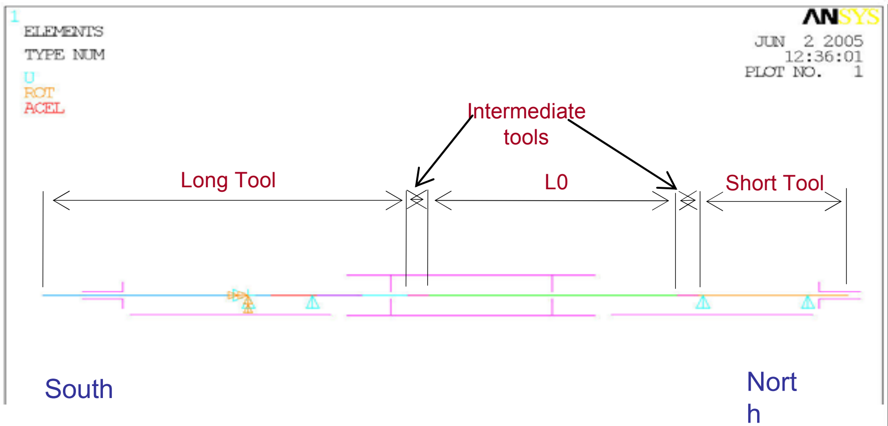
- After sliding L0 another 630 mm south and re-gripping the long tool

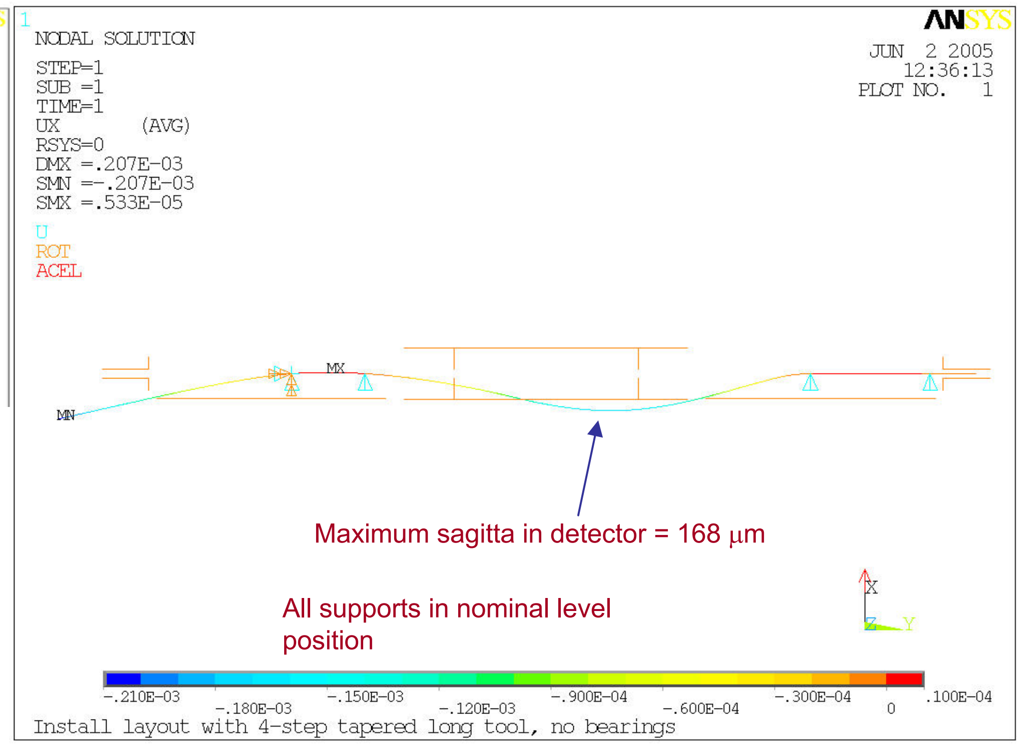




L0 Installation Deflections (4)

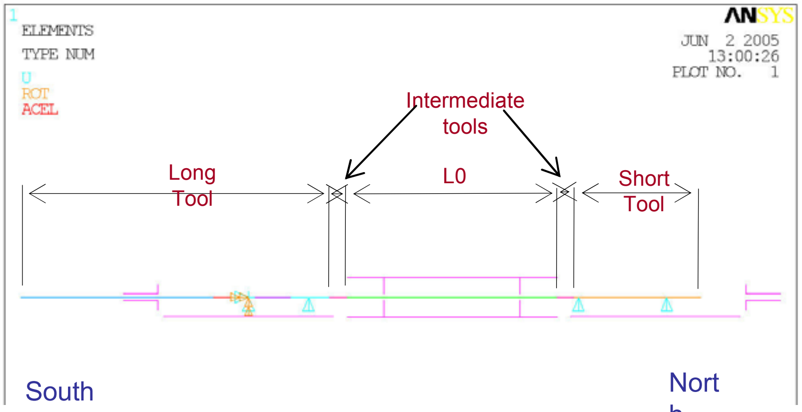
- After sliding L0 another 400 mm south, re-gripping the long tool, and adding the short tool



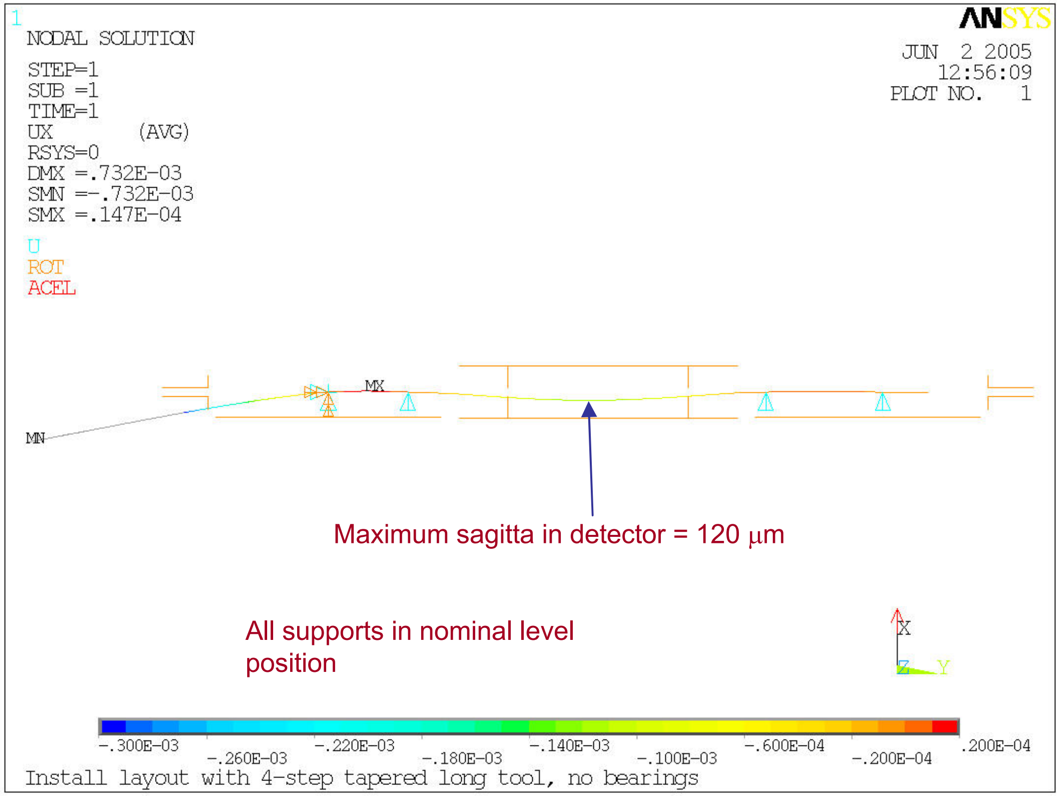


L0 Installation Deflections (5)

- After sliding L0 another 550 mm south to its final position and re-gripping the long tool



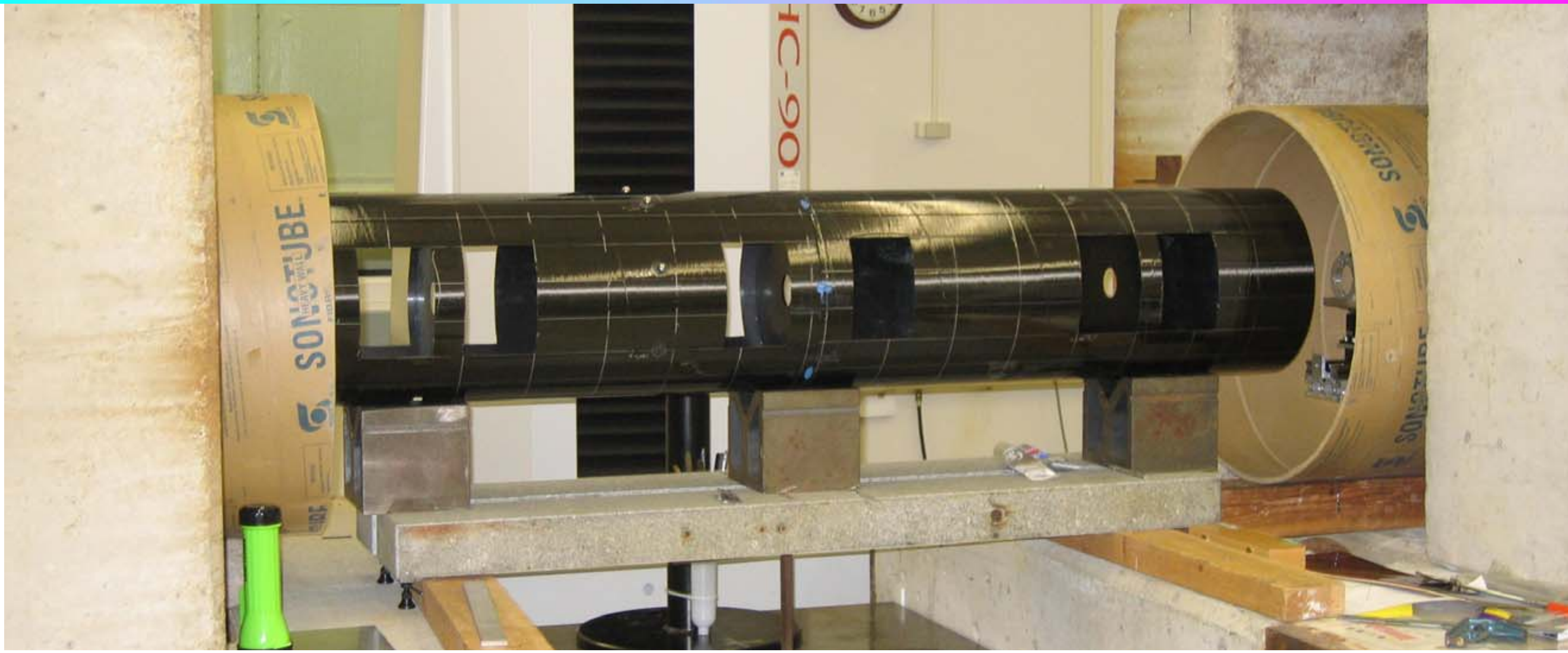
- L0 is in position to be connected to its mounts



L0 Mechanical Installation

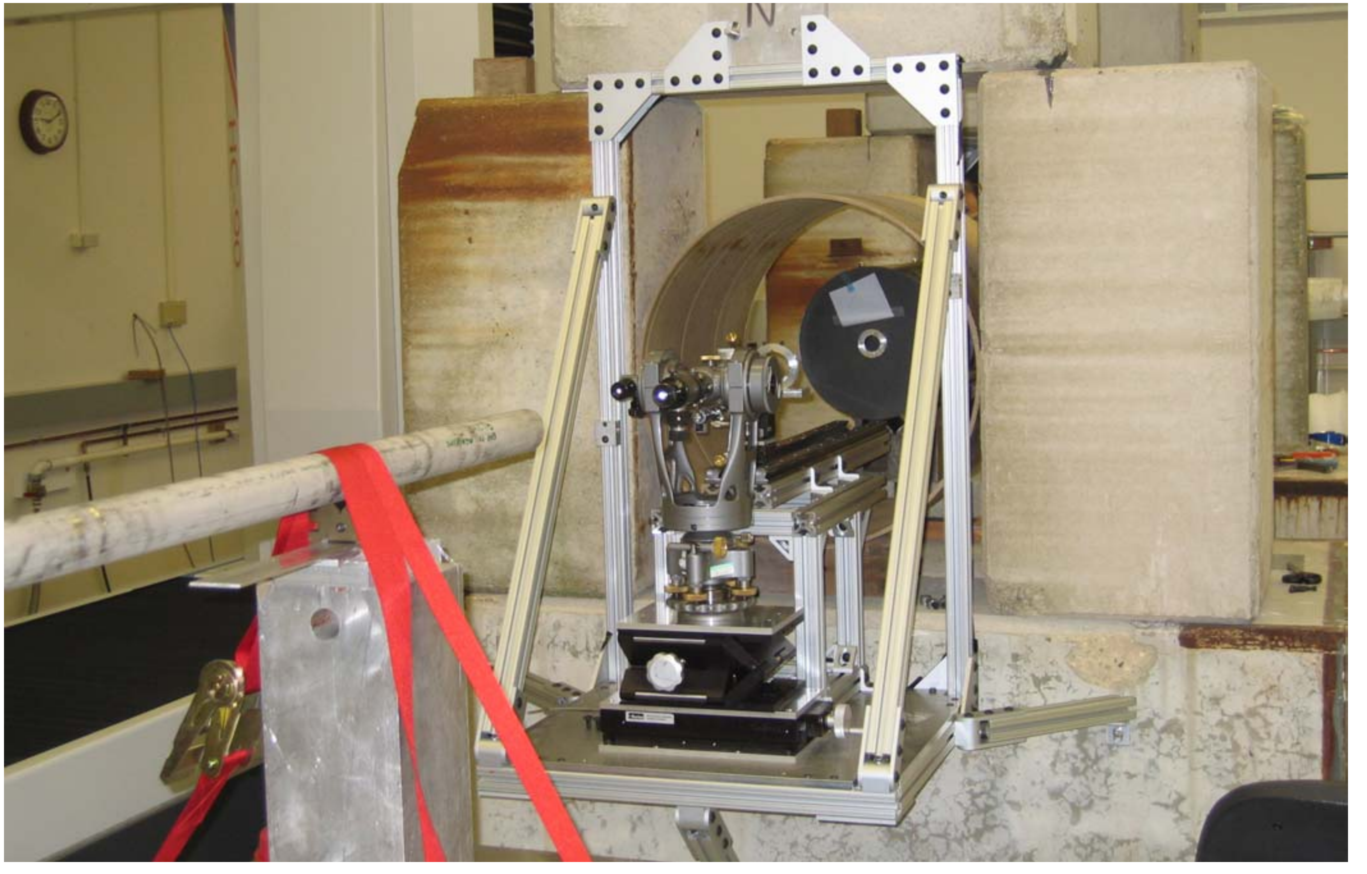
- L0 mechanical installation was tested in Lab 3 using a mock-up of the L0 structure.
  - The L0 mock-up is in the foreground; the “long installation tool” is in the background.

Lab 3 Tests of L0 Installation



- Mock installation of L0 through the Run IIa silicon aperture was successful the first try. A second test installation was also successful.
- Dave Butler, Mike Roman, Youri Orlov, and Joe Howell prepared the test.
- CF support cylinders with features matching those of Run IIa simulate the Run IIa apertures.
- Sonotubes and shielding blocks simulate features of the CFT and CC.

Lab 3 Tests of L0 Installation

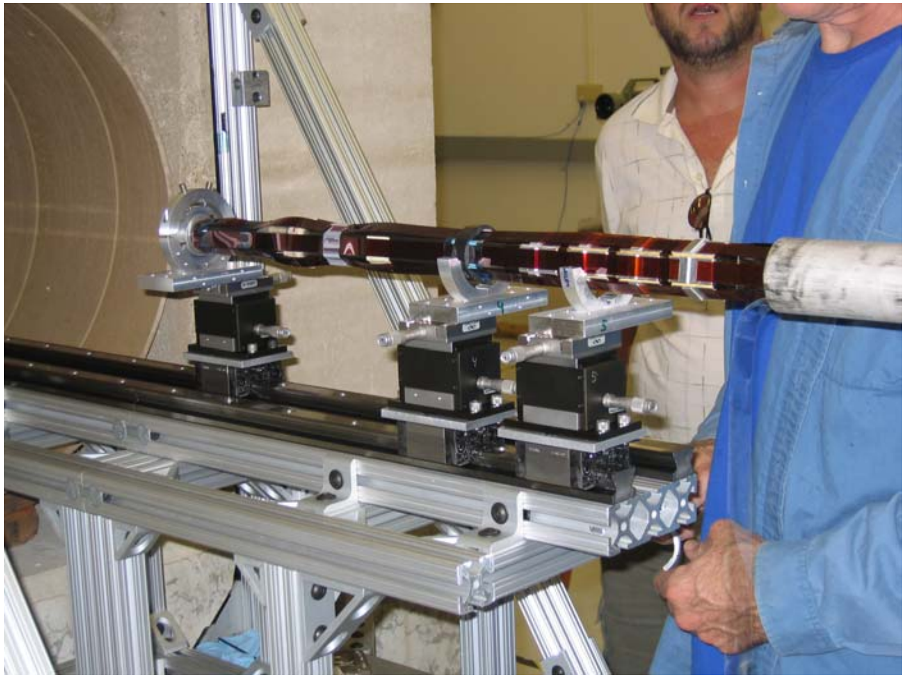


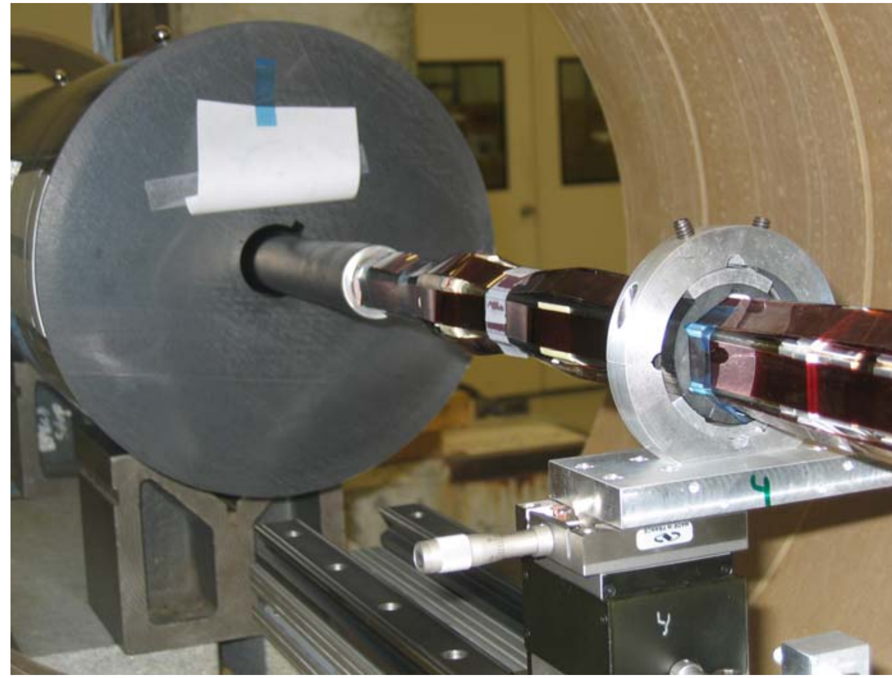
- All fixturing and procedures worked.
- Tables based on those used during the Fall 2004 aperture measurement support survey equipment and L0 installation fixturing

Lab 3 Tests of L0 Installation

- The “long installation tool” was made by U. Washington.
- The tool is cantilevered from one end as it is inserted through the Run IIa aperture.
- Multiple sets of stages allow support points to be shifted along the length of the tool as the tool is passed through the Run IIa aperture.

Lab 3 Tests of L0 Installation



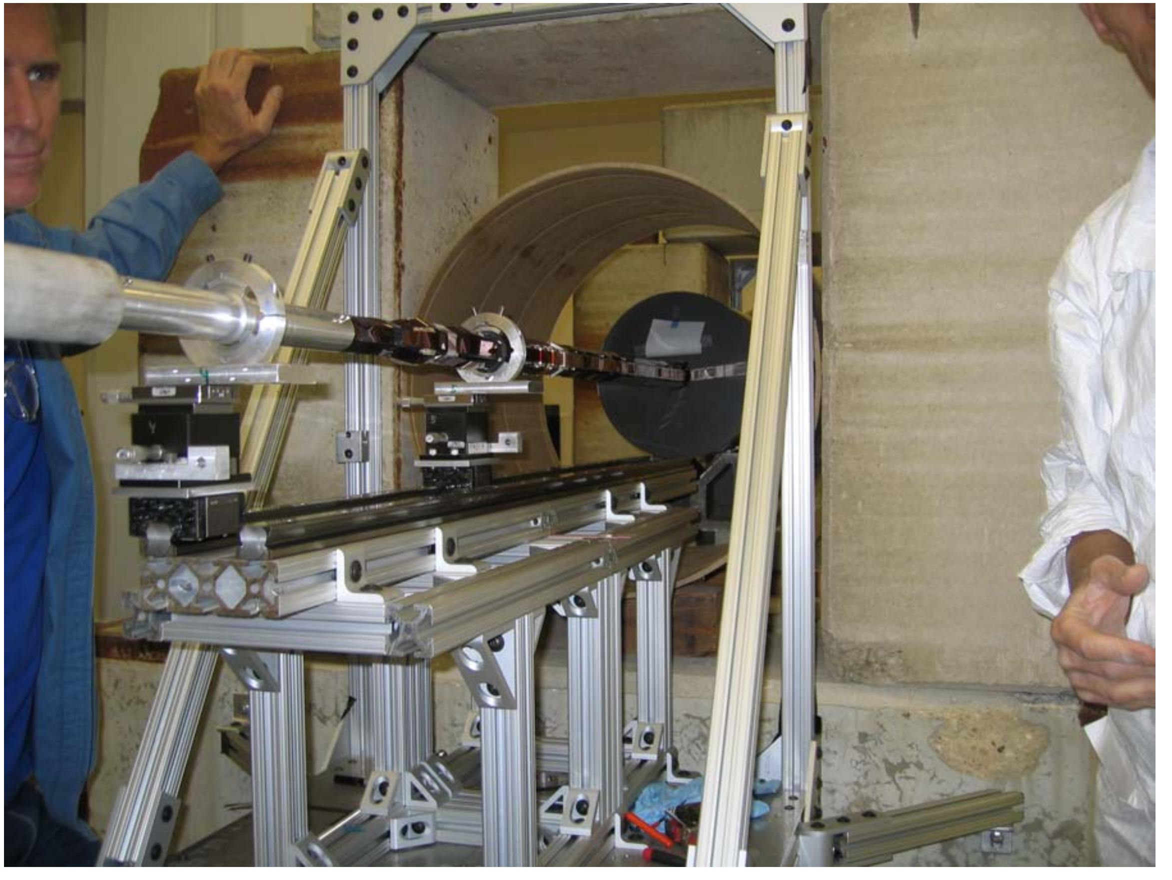


- L0 is supported via stages and rails as it is extracted from the ECN beam pipe.
- Then L0 is moved along and its intermediate tool (which aids in dressing cables) is engaged with the end of the long tool.

Lab 3 Tests of L0 Installation

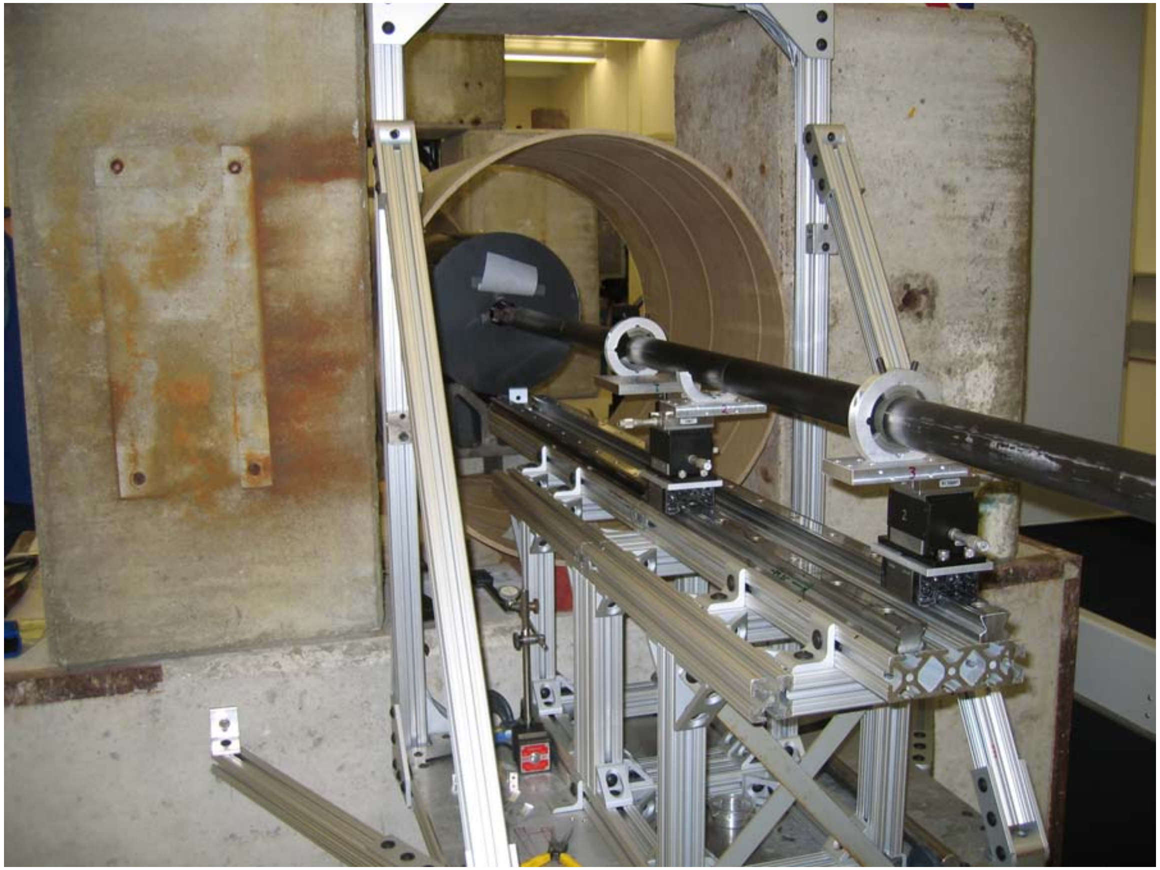
- Multiple stages allow L0 support points to be shifted as L0 is drawn into the aperture.

Lab 3 Tests of L0 Installation



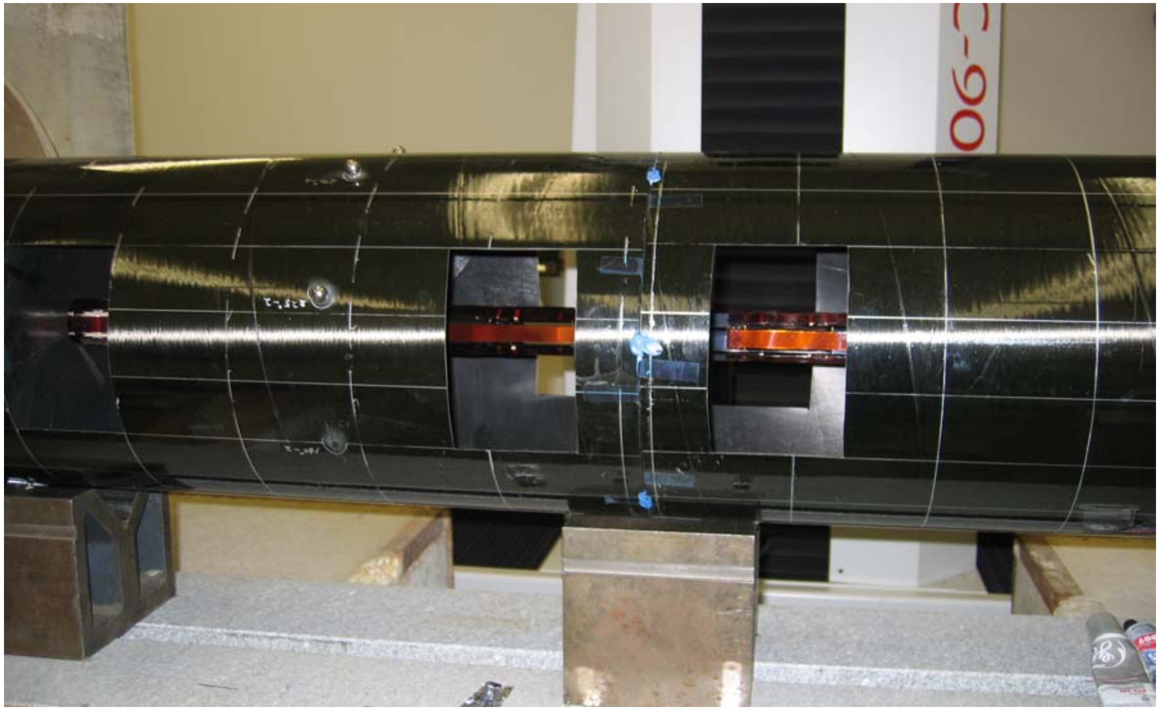
- A short, aluminum installation tool supports and guides the second end of L0 during the final stages of installation.

Lab 3 Tests of L0 Installation



- The end of L0 is emerging from the long tool end of the aperture.

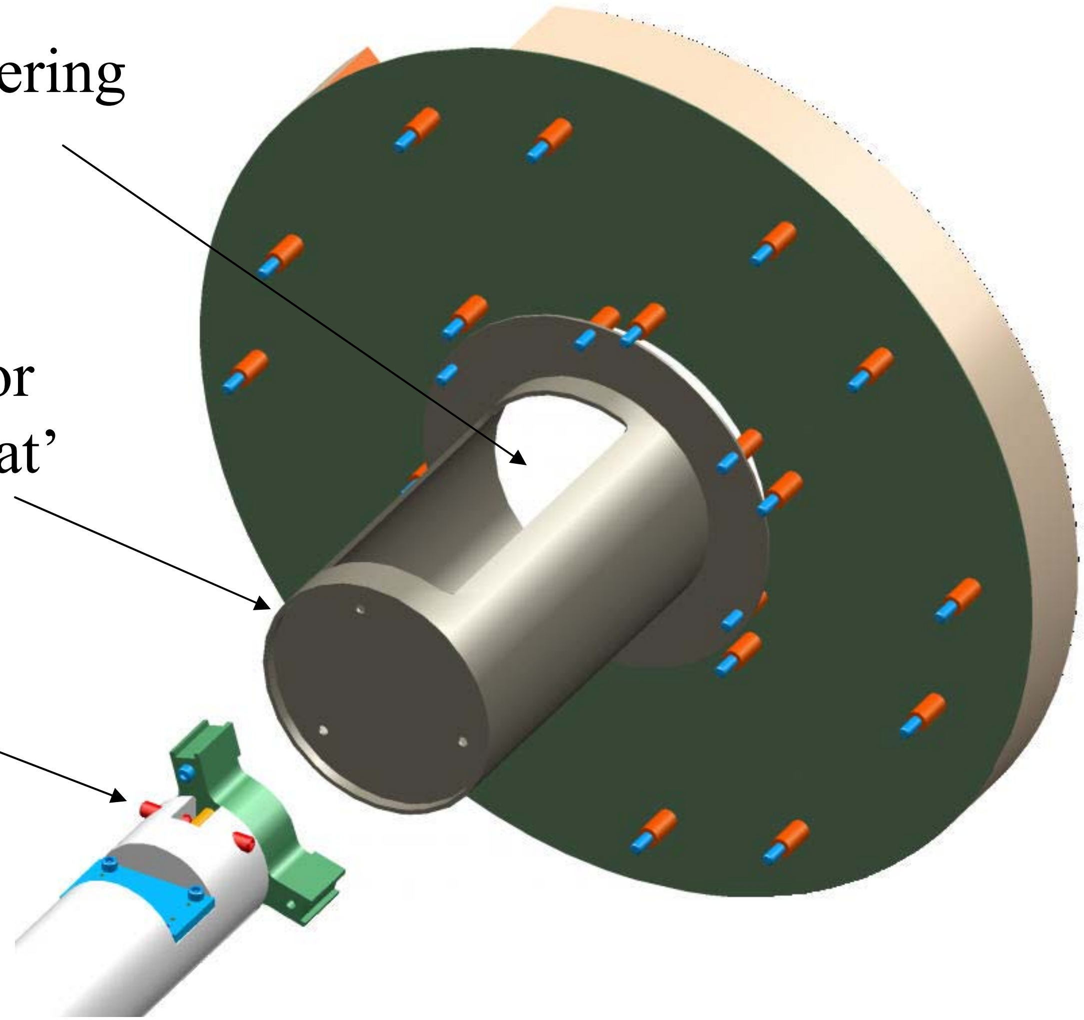
Lab 3 Tests of L0 Installation



- Support cylinder openings allowed us to observe L0 transverse positions during and after installation.
- No corrections to the installation path were based upon those observations.

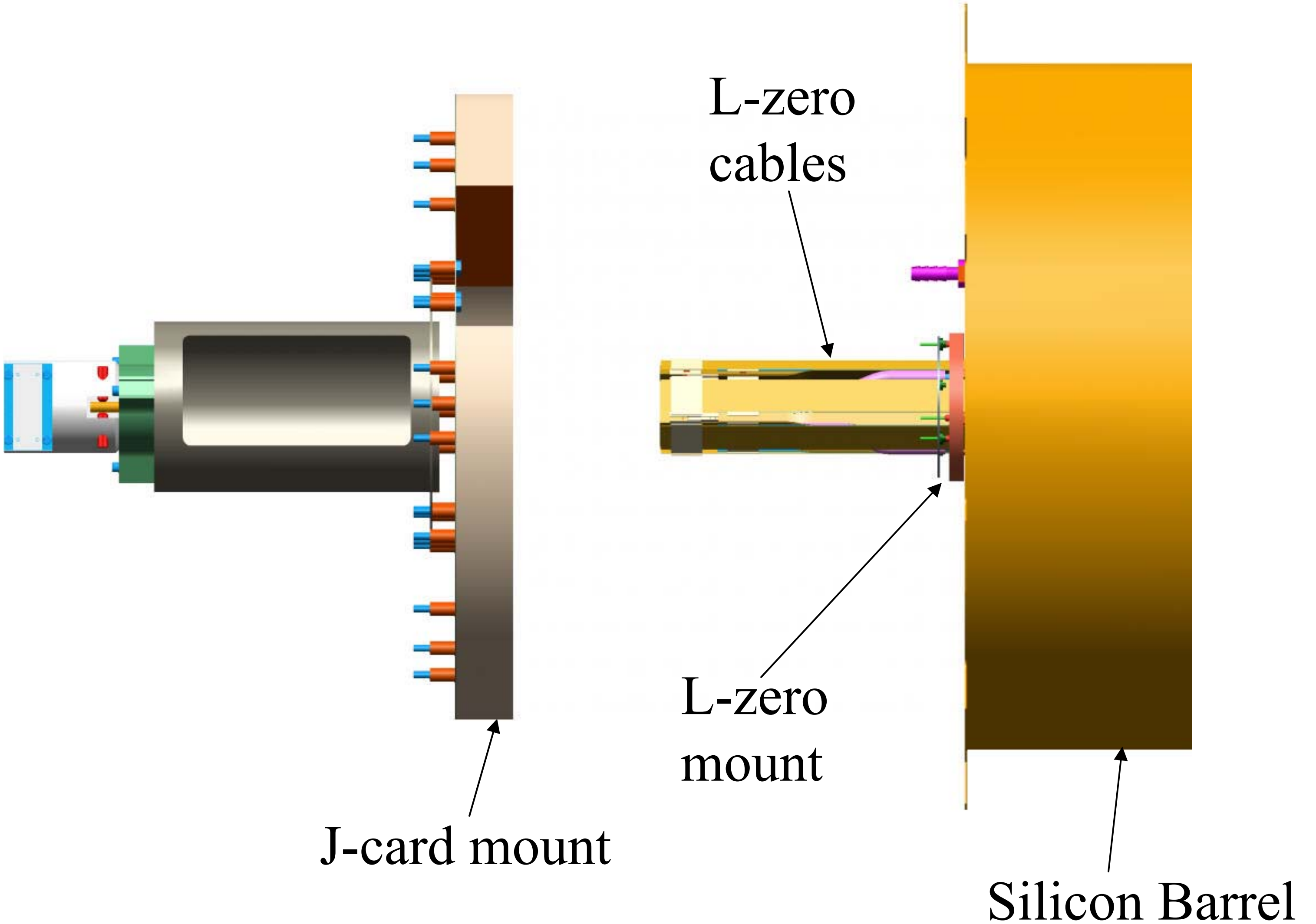
JC Mount Installation Tooling

- Junction card mounts are installed after L0 is in place.



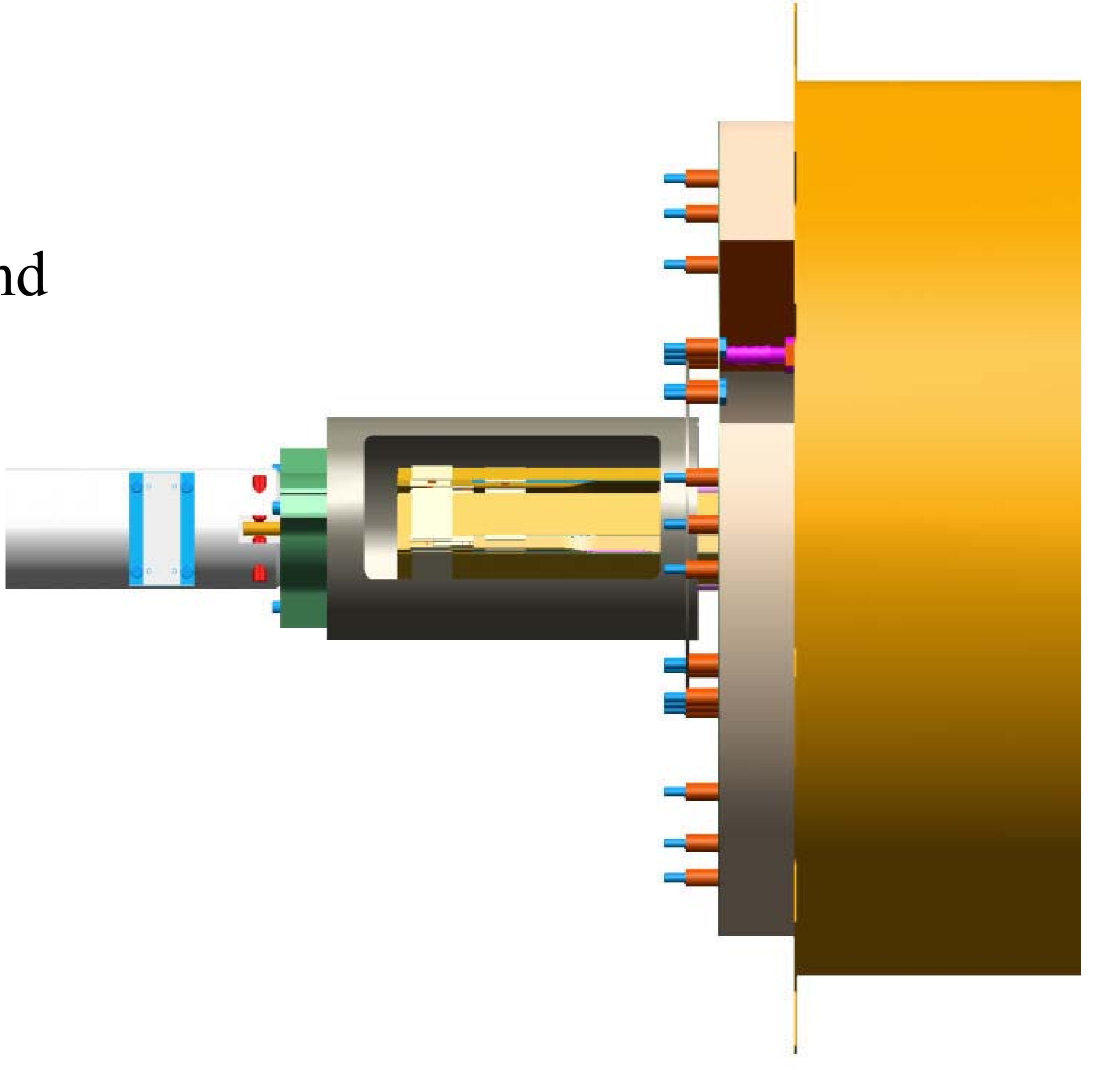
Mount design by Dan Olis

JC Mount Installation



JC Mount Installed

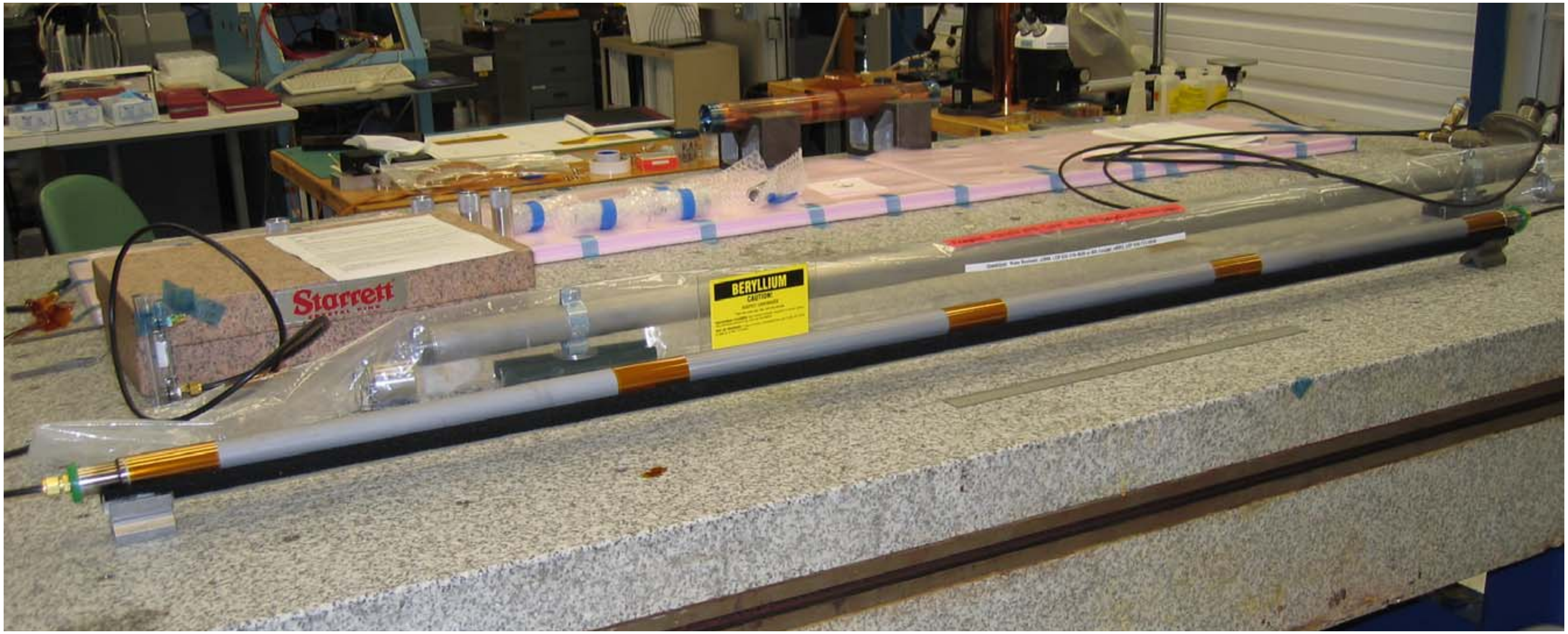
Installation tooling sleeves over cables and cooling lines.



Run IIb Beam Pipe

- The 72” long beryllium beam pipe was baked out at Brush-Wellman Electrofusion and passed helium leak checks there and at Fermilab.
- Kapton insulating wraps have been added at five locations to prevent DC electrical contact with L0.
- The beam pipe was successfully inserted into the spare L0 support structure (CS1).
  - Capacitance measurements were consistent with expectations.
- The pipe is at PAB awaiting a final bake-out and leak check.
  - Procedures for those remain to be completed and approved.
- Extensions to bring the overall beam pipe length to 96.57” have been completed and are also at PAB awaiting bake-out and leak check.

Beam Tube Insulating Wraps



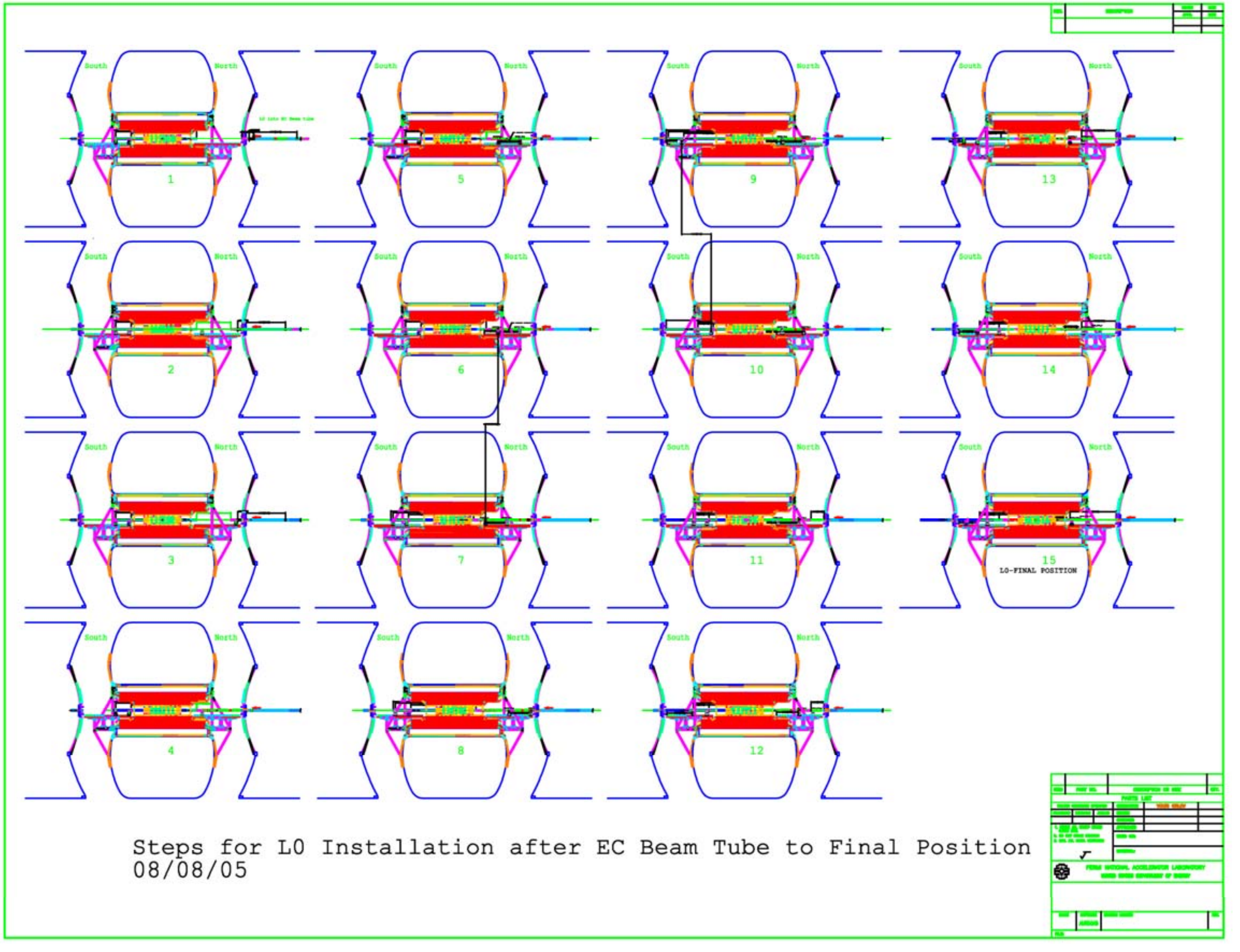
Yet to be Done

- Most of the remaining tasks could be completed with three to four weeks of concentrated effort. A 3/1/06 shutdown date opens the possibility of completing them with less haste and greater care.
  - Final confirmation of desired azimuth with respect to gravity and offsets with respect to membrane openings
  - Final measurements of L0 profile and sensor positions
  - Lab 3 tests of installation of L0 mounts and junction card mounts
  - Design and fabrication of beam pipe supports to replace those of the outer H-disks
    - Could incorporate cooling passages and mounts for silicon-based radiation sensors
  - Completion of JHA's and submission for approval
  - A trial run from SiDet to DAB
  - Final practice installations at Lab 3 and DAB
- The trail run and final practice installations should be made shortly before the shutdown, so that procedures are fresh in the minds of participants.

In Summary

- Installation tests at Lab 3 and DAB were successes.
  - Fixturing and procedures worked the first time.
- We expect installation at DAB to be equally successful.

Back-up Slide Showing Lab 3 Steps



Back-up Slide of Lab 3 Spreadsheet

- For each of fifteen steps, a spreadsheet listed Y-positions and Z-positions of L0 center, L0 ends, and tool ends. It also indicated from which rail each support was to be provided and the diameters of tool grips.

Units = inches										
	Position 1		Position 2		Position 3		Position 4		Position 5	
	Inches		Inches		Inches		Inches		Inches	
	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0
Tool_1_outer_end	-56.5		-56.5		-56.5		-56.5		-56.5	
Support 1, Rail 1	-54		-54		-54		-54		-54	-0.0131
Support 2, Rail 1	-36		-36		-36		-36		-36	-0.0057
Support 3, Rail 2										
Support 4, Rail 3									53.787	0.0020
Support 5, Rail 3									78.682	0.0020
Support 6, Rail 4					85.248		46.162			
First L0 end	92.513		79.311		79.311		40.225		40.225	0.0020
Center of L0	130.970		117.768		117.768		78.682		78.682	-0.0036
Second L0 end	169.427		156.225		156.225		117.139		117.139	0.0020
Tool_2a_outer_end										
Tool_2b_outer_end										
dZ_L0			-13.202		0		-39.086		0	
Motion										
Tool 1 grip diameter (inch)									1.560	
									1.560	

	Position 6		Position 7		Position 8		Position 9		Position 9A	
	Inches		Inches		Inches		Inches		Inches	
	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0
Tool_1_outer_end	-56.5		-71.15		-71.15		-90.65		-90.65	
Support 1, Rail 1	-54	-0.0131	-68.65	-0.0131	-68.65	-0.0131	-88.15	-0.0131	-88.15	-0.0131
Support 2, Rail 1	-36	-0.0057	-50.65	-0.0057	-50.65	-0.0057	-70.15	-0.0057	-70.15	-0.0052
Support 3, Rail 2									-54	0.0019
Support 4, Rail 3	53.062	0.0020	38.412	0.0020	88.202	0.0020	68.702	0.0020	68.702	0.0020
Support 5, Rail 3	77.957	0.0020	63.307	0.0020	63.307	0.0020	43.807	0.0020	43.807	0.0020
Support 6, Rail 4										
First L0 end	39.5	0.0020	24.85	0.0020	24.85	0.0020	5.35	0.0020	5.35	0.0020
Center of L0	77.957	-0.0036	63.307	-0.0036	63.307	-0.0036	43.807	-0.0036	43.807	-0.0036
Second L0 end	116.415	0.0020	101.765	0.0020	101.765	0.0020	82.265	0.0020	82.265	0.0020
Tool_2a_outer_end										
Tool_2b_outer_end										
dZ_L0	-0.725		-14.65		0		-19.500		0	
Motion										
Tool 1 grip diameter (inch)	1.560		1.560		1.560		1.560		1.560	
	1.560		1.560		1.560		1.560		1.560	

	Position 10		Position 11		Position 12		Position 13		Position 14		Position 15	
	Inches		Inches		Inches		Inches		Inches		Inches	
	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0	Z_D0	Y_D0
Tool_1_outer_end	-90.65		-95.9		-95.9		-120.9		-120.9		-134.4573	
Support 1, Rail 1	-36	-0.0005	-41.25	-0.0005	-41.25	-0.0005	-66.25	-0.0005	-66.25	0.0019	-79.807	0.0019
Support 2, Rail 1			-59.25	0.0019	-59.25	0.0019	-84.25	0.0019	-43.616	0.0021	-57.174	0.0021
Support 3, Rail 2	-54	0.0019										
Support 4, Rail 3	68.702	0.0020	63.452	0.0020	63.452	0.0020	38.452	0.0020	54.034	0.0020	40.477	0.0020
Support 5, Rail 3	43.807	0.0020	38.557	0.0020	79.034	0.0020	54.034	0.0020	73.158	0.0020	59.600	0.0020
Support 6, Rail 4												
First L0 end	5.35	0.0020	0.1	0.0020	0.1	0.0020	-24.9	0.0020	-24.9	0.0020	-38.457	0.0020
Center of L0	43.807	-0.0036	38.557	-0.0036	38.557	-0.0036	13.557	-0.0036	13.557	-0.0036	0	-0.0036
Second L0 end	82.265	0.0020	77.015	0.0020	77.015	0.0020	52.015	0.0020	52.015	0.0020	38.457	0.0020
Tool_2a_outer_end			89.015	0.0025	89.015	0.0025	64.015	0.0025	64.015	0.0025	50.457	0.0025
Tool_2b_outer_end									76.015	0.0025	62.457	0.0025
dZ_L0	0		-5.25		0		-25.000		0		-13.557	
Motion												
Tool 1 grip diameter (inch)	1.560		1.560		1.560		1.560		1.560		1.560	
	1.560		1.560		1.560		1.560		1.466		1.466	

Layer 0 Installation Risks

- The completed aperture measurements and measurements of Layer 0 that will be conducted as it is assembled should ensure that Layer 0 will fit within the available space.
- Then the primary risks are associated with the installation process.
  - Run IIa silicon or its support structure might be damaged.
  - Layer 0 silicon might be damaged.
- Secondary risks associated with installation are that:
  - Beam pipe connections might leak.
  - Silicon coolant connections might leak.
  - Inner H-disks might be damaged.
  - Beryllium contamination might occur.
  - Fiber tracker wave-guides might be damaged.
  - Run IIa silicon cables might be damaged.

From Director's Review – February 3, 2005

These statements remain valid.

General Mitigation of Risks

- A draft proposal outlining steps and hazards associated with Layer 0 installation has been presented to the Layer 0 group and Run IIb project and installation managers.
- That proposal has been incorporated by Russ Rucinski in a draft of the procedures to be followed for D0 operations during the Layer 0 installation shutdown.
- Personnel gained experience in similar, but less complex operations during aperture measurements last fall.
- Installation procedures will be documented, reviewed and many will be tested before their use at D0.

From Director's Review – February 3, 2005

Procedures have been tested at Lab 3 and DAB.

Overall procedures were last updated 8/16/05 and are posted:

http://d0server1.fnal.gov/users/lipton/www/Proc/Procedures.html

Evaluation & Mitigation of Primary Risks

- Based upon measurements, the smallest available aperture at D0 is represented by an ellipse with horizontal and vertical axes of half-length 22.88 mm and 23.69 mm, respectively.
- The original design radius of Layer 0 was 22.02 mm, leaving a horizontal radial clearance of 0.86 mm and a vertical radial clearance of 1.67 mm.
- During assembly of Layer 0, we will require that the 22.02 mm radius not be exceeded.
  - The thickness of received hybrids is known to satisfy specifications.
  - Changes have already been made to reduce the thickness of cables and associated spacers.
  - The thickness of spacers to set hybrid radial positions will be reduced to match the thinner cables and to take into account measurement results for cable stacks.
  - Provided those changes are successfully implemented and good alignment of parts is maintained as Layer 0 is assembled, sensor corners should set the maximum Layer 0 radius = 21.26 mm.

From Director's Review – February 3, 2005

Dimensions we have checked met spec.

Evaluation & Mitigation of Primary Risks

- The design and testing of installation fixtures will assume the larger Layer 0 radius, 22.02 mm, and available clearances of 0.86 mm horizontally and 1.67 mm vertically.
- Fixtures will be designed to control Layer 0 transverse position during installation to ± 0.50 mm vertically and ±0.25 mm horizontally.
  - That will be tested at SiDet.
- We will ensure that installation fixtures are aligned at D0 to better than ± 0.50 mm vertically and ±0.25 mm horizontally taking into account lever arms associated with installation tool extension.
  - That will be tested at D0 using optical instruments to observe the motion of the installation tool.
- The result should be worst case remaining radial clearances of 0.86 – 0.25 – 0.25 = 0.36 mm horizontally and 1.67 – 0.50 – 0.50 = 0.67 mm vertically.
- Should measurements demonstrate that Layer 0 is smaller, one-quarter of the additional clearance would be allocated to tolerance for tool motion and one-quarter would be allocated to tolerance for fixture alignment.

From Director’s Review – February 3, 2005

These statements remain valid.

Evaluation & Mitigation of Secondary Risks

- Except for connections to the new beryllium beam pipe, most secondary risks have been encountered previously at D0.
- Beam pipe flange connections for the Run IIb beam pipe employ the same basic design as those of the Run IIa beam pipe, but are scaled to a smaller diameter. No difficulties have been encountered in obtaining leak-tight connections during leak checks and bake-out at Brush-Wellman Electrofusion or leak checks at Fermilab. We will face the difficulty of making up the connections at arms length as part of Layer 0 installation. That will be tested by making up flange assemblies (without a beam pipe) in a mock-up with similar access constraints.
- H-disk removal, reinstallation of inner H-disks, and work involving H-disk and Layer 0 cooling connections will be based upon procedures used for the original Run IIa installation. Since some personnel involved in the original work are no longer available, fixtures and procedures will be reviewed in considerable detail with personnel who would perform the work. Our ability to make cooling connections will have been verified in preparations for the full system test at SiDet.

These statements remain valid. We will follow conditions of the third point.

Cooling connections were made at SiDet without difficulties.

From Director's Review – February 3, 2005

Evaluation & Mitigation of Secondary Risks

- Remaining secondary issues will be addressed by following procedures used successfully during the original Run IIa installation and during last fall's silicon aperture measurements.
- As was the case for the aperture measurement, PPD safety will review procedures for work involving the beam pipe and provide guidance on any changes needed from those used last fall.

From Director's Review – February 3, 2005

These statements remain valid.